09/913353
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Practitioner's Docket No.: 789_071 *PATENT*

IN THE UNITED STATES DESIGNATED OFFICE (DO/US)

PCT/JP00/09133	22 December 2000	24 December 1999
INTERNATIONAL APPLICATION NO.	INTERNATIONAL FILING DATE	PRIORITY DATE CLAIMED

TITLE OF INVENTION
HEAT SINK MATERIAL AND METHOD OF PRODUCING THE SAME

APPLICANT(S) FOR DO/US
Shuhei ISHIKAWA, Tsutomu MITSUI, Ken SUZUKI, Nobuaki NAKAYAMA, Hiroyuki TAKEUCHI and Seiji YASUI

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Elizabeth A. VanAntwerp

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Box PCT
Assistant Commissioner for Patents
Washington, D.C. 20231

Attention: DO/US

SUBMISSION OF PROPOSED DRAWING AMENDMENT FOR APPROVAL BY EXAMINER

Sir:

Attached please find

(check applicable items)

[x] a copy of the original drawings (Figs. 21 and 24) with red ink markings, showing the proposed changes to the drawings in this application, and

[x] if drawings are approved by the Examiner, we also enclose formal drawings for Figs. 21 and 24.

Respectfully submitted,

August 13, 2001
Date

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FIG. 21

SAMPLE	SIZE (mm)	METAL	ADDITIVE ELEMENT	AMOUNT OF ADDITION (wt%)	IMPREGNATING METHOD	IMPREGNATION PRESSURE (MPa)	COEFFICIENT OF THERMAL CONDUCTIVITY (W/mK)		COEFFICIENT OF THERMAL EXPANSION ($\times 10^{-6}$/K) SURFACE	COEFFICIENT OF THERMAL EXPANSION ($\times 10^{-6}$/K) THICKNESS	BENDING STRENGTH (MPa) SURFACE	BENDING STRENGTH (MPa) THICKNESS	COMPRESSIVE STRENGTH (MPa) SURFACE	COMPRESSIVE STRENGTH (MPa) THICKNESS	WATER RESISTANCE	EFFECT
n1-1	20×60×60	Al	NONE	NONE	PRESS	26.7	156	311	5.5	6.0	31.4	51.9	46.1	51.0	△	NONE
n1-4	20×120×190	Al	NONE	NONE	PRESS	60.0	185	350	5.5	6.5					△	NONE
n1-2	20×60×60	Cu	NONE	NONE	PRESS	26.7	150	310	3.8	4.5	26.5	39.2			◎	NONE
n1-3	20×120×190	Cu	NONE	NONE	PRESS	26.7	147	268	3.9	4.5	26.5	39.2			◎	NONE
n2-1	20×60×60	Cu	Te	0.500	PRESS	26.7	190	351	3.8	4.5	26.5	39.2			◎	WETTABILITY
n3-1	20×60×60	Cu	Be	1.000	PRESS	26.7	183	341	3.8	4.5	38.2	62.7			△	GENERATION OF CARBIDE
n3-2	20×120×190	Cu	Be	1.000	PRESS	156.1	189	342	4.0	4.6	37.2	61.7			△	
n3-3	20×60×60	Cu	Cr	0.500	PRESS	26.7	180	320	3.8	4.5	36.3	59.8			△	
n3-4	20×60×60	Cu	Mn	0.500	PRESS	26.7	176	330	3.8	4.5	34.3	55.9	42.1	48.0	△	
n3-5	20×60×60	Cu	Nb	0.050	PRESS	156.1	198	336	3.8	4.5	35.3	57.8			△	
n3-6	20×120×190	Cu	Nb	0.050	PRESS	26.7	167	309	3.8	4.5	35.3	57.8			△	
n3-7	20×60×60	Cu	Zr	0.500	PRESS	26.7	158	312	3.8	4.5	34.3	56.8			△	
n3-8	20×120×190	Cu	Nb	0.001	PRESS	43.3	182	352	4.5	3.0			40.2	51.9	△	
n3-9	20×120×190	Cu	Nb	0.001	PRESS	60.0	182	363	4.0	3.0			42.1	51.9	△	
n3-10	20×120×190	Cu	Nb	1.100	PRESS	60.0	196	359	4.0	2.5			51.0	58.8	△	
n3-11	20×120×190	Cu	Be	1.900	PRESS	60.0	186	366	4.5	3.5			57.8	64.7	△	
n3-12	20×120×190	Cu	Ni, Sn	9.4, 6.7	PRESS	60.0	190	343					51.9	51.0	◎	COMBINED ADDITION
n3-13	20×120×190	Cu	Ni, Si, P	1.0, 0.23, 0.04	PRESS	60.0	190	353					48.0	51.9	○	
n3-14	20×120×190	Cu	Mn	4.180	PRESS	60.0	181	352					51.0	54.9	△	GENERATION OF CARBIDE
n3-15	20×120×190	Cu	Cr	2.870	PRESS	60.0	195	387					48.0	51.9	△	
n3-16	20×120×190	Cu	Zr	4.490	PRESS	60.0	207	367					53.9	63.7	△	
n3-17	20×120×190	Cu	Si	11.300	PRESS	26.7	157	333					53.9	60.8	◎	EXPANSION OF SOLID-LIQUID RANGE
n3-18	20×120×190	Cu	Si	10.900	PRESS	60.0	159	316					56.8	68.6	◎	
n3-19	20×120×190	Cu	Si	5.170	PRESS	153.0	165	343					52.9	62.7	◎	
n3-20	20×120×190	Cu	Si	5.300	PRESS	43.3	163	325					54.9	60.8	◎	
n5-1	20×60×60	Cu	NONE	NONE	GAS	26.7	170	320	3.8	4.5	26.5	39.2			◎	NONE
n7-1	20×120×190	Al	Be	2.000	PRESS	60.0	177	332	5.0	6.5			57.8	62.7	△	GENERATION OF CARBIDE
n7-2	20×120×190	Al	Si	5.000	PRESS	60.0	169	329	5.0	6.5			50.0	61.7	◎	EXPANSION OF SOLID-LIQUID RANGE
n7-3	20×120×190	Al	Si	12.000	PRESS	60.0	181	327	5.0	6.5			56.8	68.6	◎	

FIG. 24

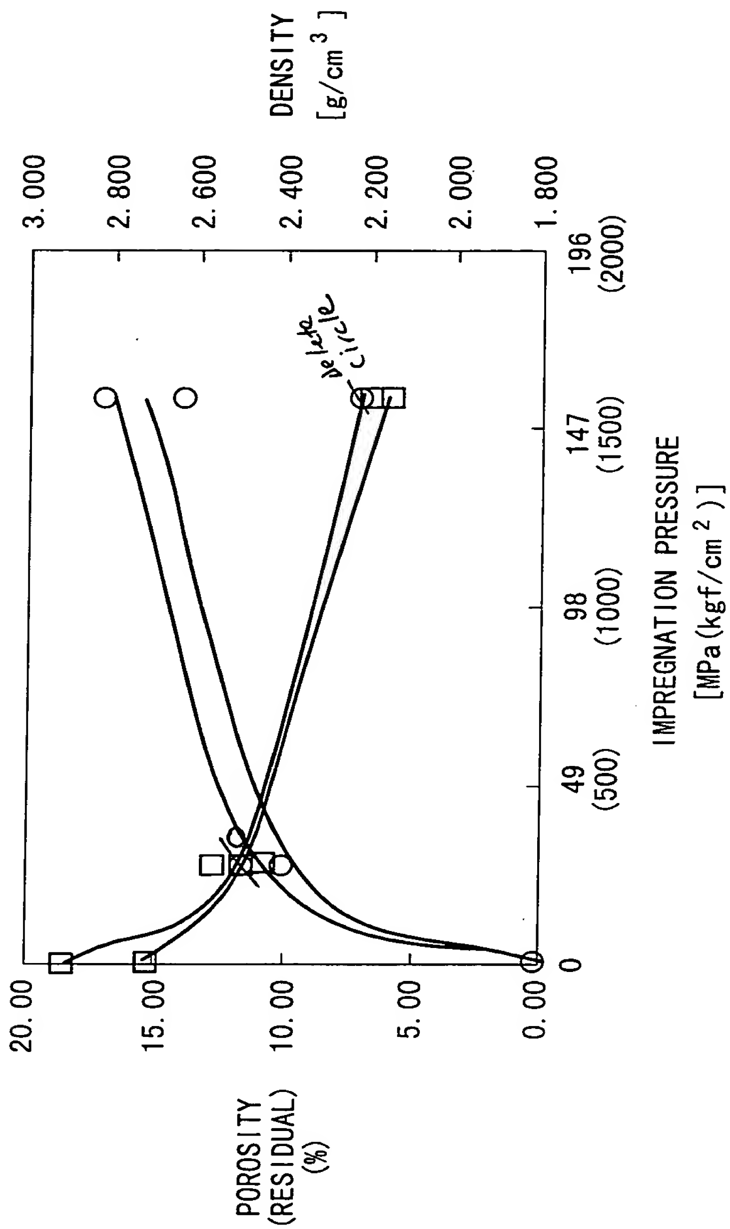
DENSITY [g/cm^3]
3.000
2.800
2.600
2.400
2.200
2.000
1.800
POROSITY (RESIDUAL) (%)
20.00
15.00
10.00
5.00
0.00
0
49 (500)
98 (1000)
147 (1500)
196 (2000)
IMPREGNATION PRESSURE [MPa(kgf/cm^2)]
Delete circle

FIG. 21

SAMPLE	SIZE (mm)	METAL	ADDITIVE ELEMENT	AMOUNT OF ADDITION (wt%)	IMPREGNATING METHOD	IMPREGNATION PRESSURE (MPa)	COEFFICIENT OF THERMAL CONDUCTIVITY (W/mK)		COEFFICIENT OF THERMAL EXPANSION ($\times 10^{-6}$/K) SUR-FACE	COEFFICIENT OF THERMAL EXPANSION ($\times 10^{-6}$/K) THICK-NESS	BENDING STRENGTH (MPa) SUR-FACE	BENDING STRENGTH (MPa) THICK-NESS	COMPRESSIVE STRENGTH (MPa) SUR-FACE	COMPRESSIVE STRENGTH (MPa) THICK-NESS	WATER RESISTANCE	EFFECT
n1-1	20×60×60	Al	NONE	NONE	PRESS	26.7	156	311	5.5	6.0	31.4	51.9	46.1	51.0	△	NONE
n1-4	20×120×190	Al	NONE	NONE	PRESS	60.0	185	350	5.5	6.5					△	NONE
n1-2	20×60×60	Cu	NONE	NONE	PRESS	26.7	150	310	3.8	4.5	26.5	39.2			◎	NONE
n1-3	20×120×190	Cu	NONE	NONE	PRESS	26.7	147	268	3.9	4.5	26.5	39.2			◎	NONE
n2-1	20×60×60	Cu	Te	0.500	PRESS	26.7	190	351	3.8	4.5	26.5	39.2			◎	WETTABILITY
n3-1	20×60×60	Cu	Be	1.000	PRESS	26.7	183	341	3.8	4.5	38.2	62.7			△	GENERATION OF CARBIDE
n3-2	20×120×190	Cu	Be	1.000	PRESS	156.1	189	342	4.0	4.6	37.2	61.7			△	
n3-3	20×60×60	Cu	Cr	0.500	PRESS	26.7	180	320	3.8	4.5	36.3	59.8			△	
n3-4	20×60×60	Cu	Mn	0.500	PRESS	26.7	176	330	3.8	4.5	34.3	55.9	42.1	48.0	△	
n3-5	20×60×60	Cu	Nb	0.050	PRESS	156.1	198	336	3.8	4.5	35.3	57.8			△	
n3-6	20×120×190	Cu	Nb	0.050	PRESS	26.7	167	309	3.8	4.5	35.3	57.8			△	
n3-7	20×60×60	Cu	Zr	0.500	PRESS	26.7	158	312	3.8	4.5	34.3	56.8			△	
n3-8	20×120×190	Cu	Nb	0.001	PRESS	43.3	182	352	4.5	3.0			40.2	51.9	△	
n3-9	20×120×190	Cu	Nb	0.001	PRESS	60.0	182	363	4.0	3.0			42.1	51.9	△	
n3-10	20×120×190	Cu	Nb	1.100	PRESS	60.0	196	359	4.0	2.5			51.0	58.8	△	
n3-11	20×120×190	Cu	Be	1.900	PRESS	60.0	186	366	4.5	3.5			57.8	64.7	△	
n3-12	20×120×190	Cu	Ni, Sn	9.4, 6.7	PRESS	60.0	190	343					51.9	51.0	◎	COMBINED ADDITION
n3-13	20×120×190	Cu	Ni, Si, P	1.0, 0.23, 0.04	PRESS	60.0	190	353					48.0	51.9	○	
n3-14	20×120×190	Cu	Mn	4.180	PRESS	60.0	181	352					51.0	54.9	△	GENERATION OF CARBIDE
n3-15	20×120×190	Cu	Cr	2.870	PRESS	60.0	195	387					48.0	51.9	△	
n3-16	20×120×190	Cu	Zr	4.490	PRESS	60.0	207	367					53.9	63.7	△	
n3-17	20×120×190	Cu	Si	11.300	PRESS	26.7	157	333					53.9	60.8	◎	EXPANSION OF SOLID-LIQUID RANGE
n3-18	20×120×190	Cu	Si	10.900	PRESS	60.0	159	316					56.8	68.6	◎	
n3-19	20×120×190	Cu	Si	5.170	PRESS	153.0	165	343					52.9	62.7	◎	
n3-20	20×120×190	Cu	Si	5.300	PRESS	43.3	163	325					54.9	60.8	◎	
n5-1	20×60×60	Cu	NONE	NONE	GAS	26.7	170	320	3.8	4.5	26.5	39.2			◎	NONE
n7-1	20×120×190	Al	Be	2.000	PRESS	60.0	177	332	5.0	6.5			57.8	62.7	△	GENERATION OF CARBIDE
n7-2	20×120×190	Al	Si	5.000	PRESS	60.0	169	329	5.0	6.5			50.0	61.7	◎	EXPANSION OF SOLID-LIQUID RANGE
n7-3	20×120×190	Al	Si	12.000	PRESS	60.0	181	327	5.0	6.5			56.8	68.6	◎	

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FIG. 24

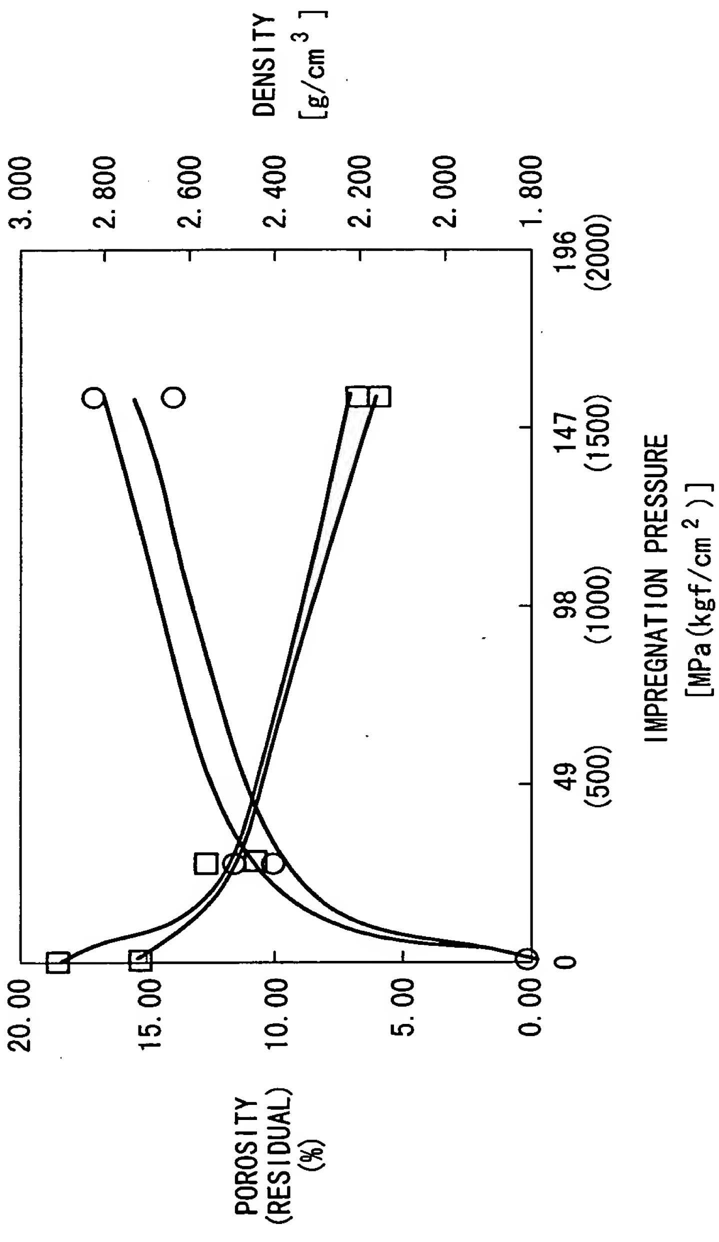
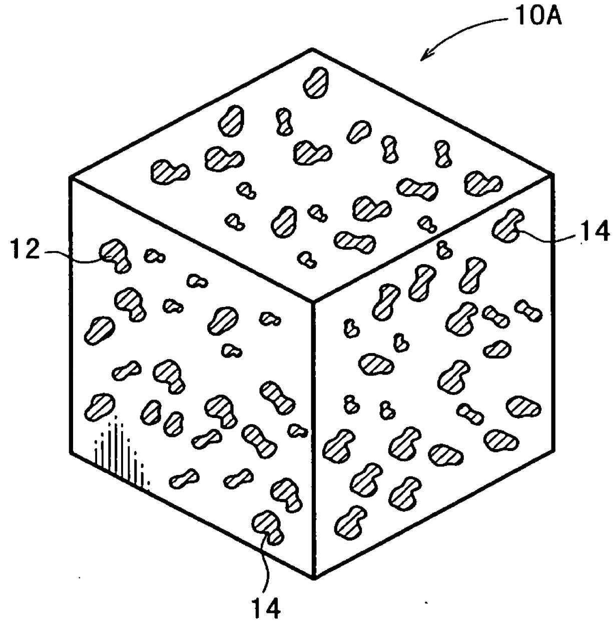


FIG. 1



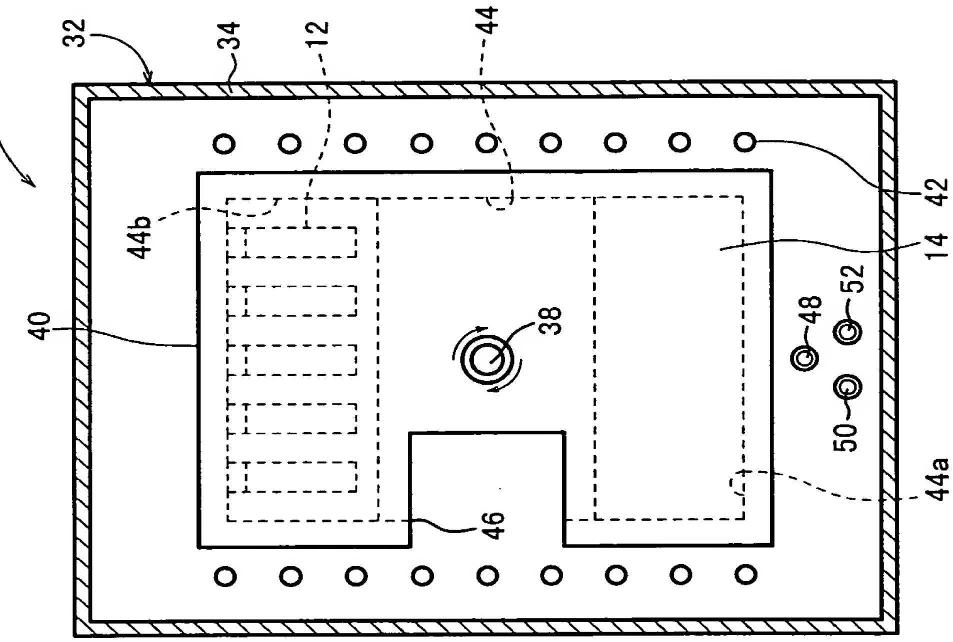

30
32
34
12
44
42
14
52
48
38
50
44a
46
44b
40

FIG. 2B

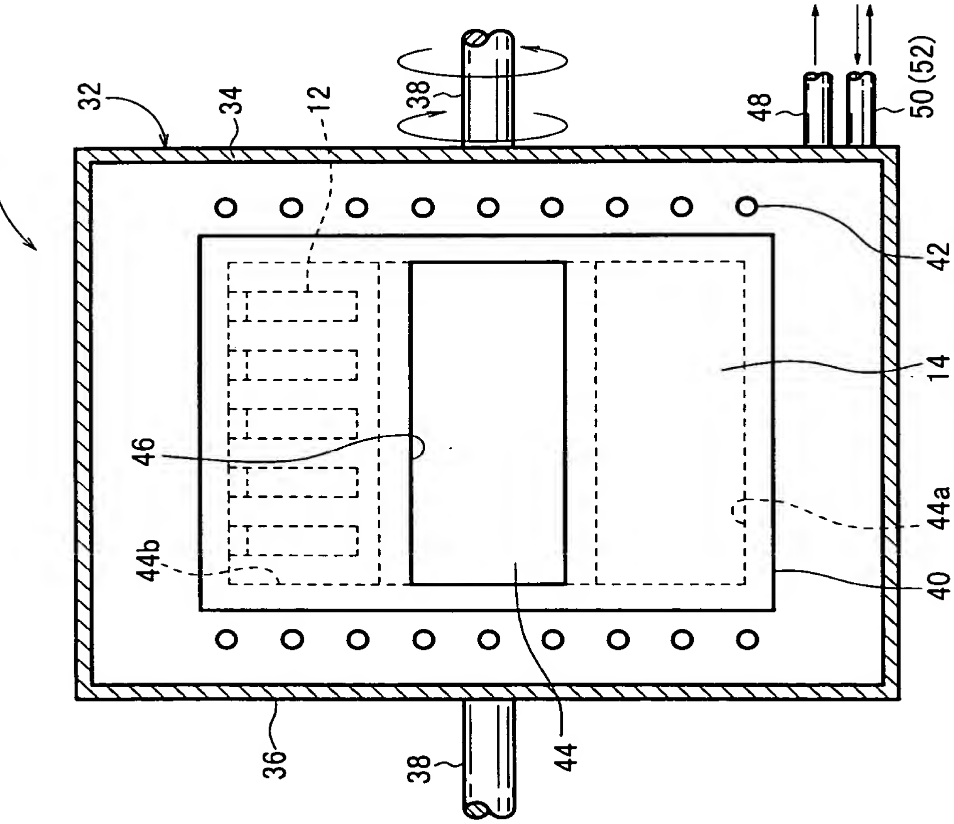

30
32
34
12
38
48
50 (52)
42
14
46
44a
44b
40
36
38
44

FIG. 2A

FIG. 3

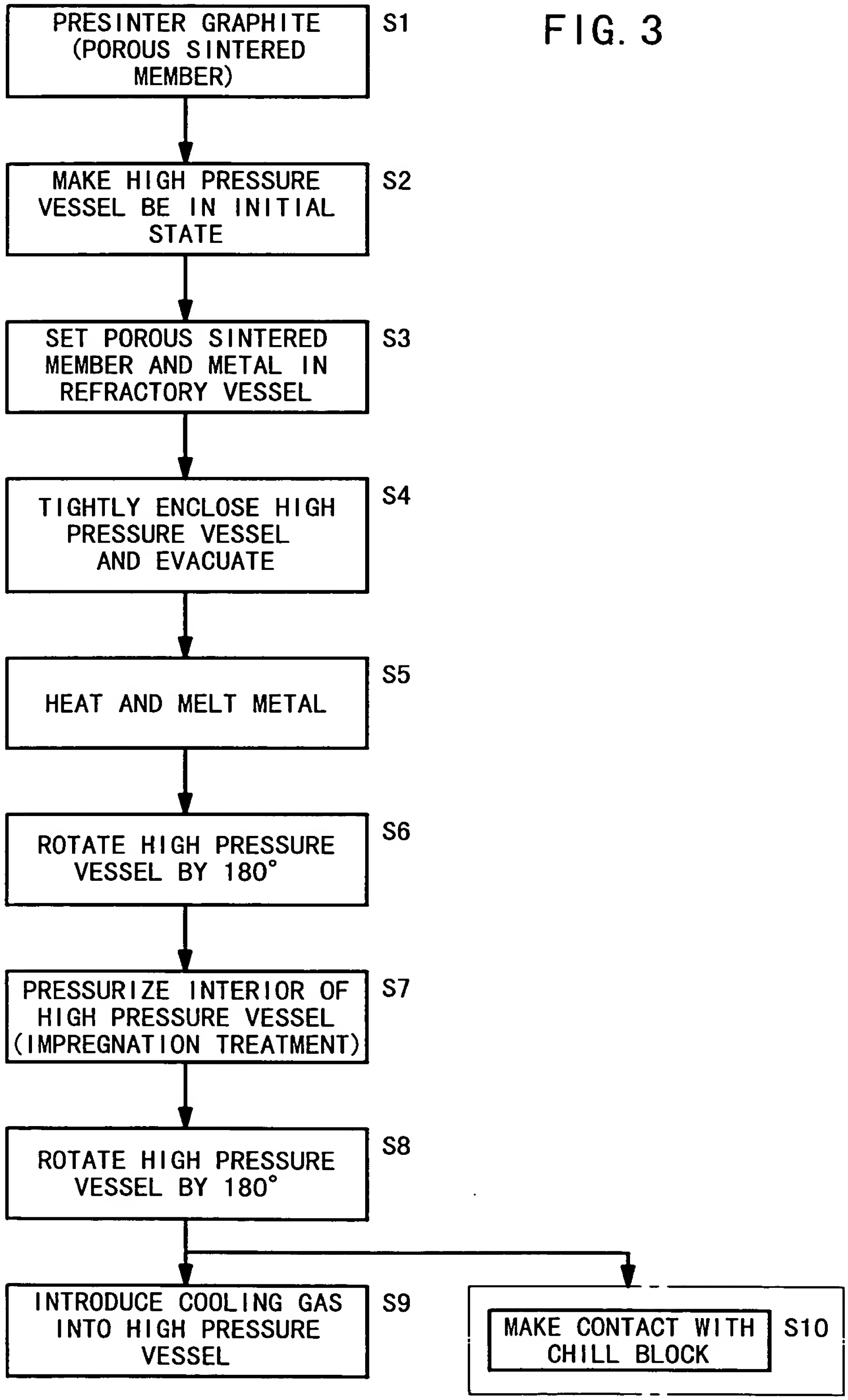

PRESINTER GRAPHITE (POROUS SINTERED MEMBER)
S1
MAKE HIGH PRESSURE VESSEL BE IN INITIAL STATE
S2
SET POROUS SINTERED MEMBER AND METAL IN REFRACTORY VESSEL
S3
TIGHTLY ENCLOSE HIGH PRESSURE VESSEL AND EVACUATE
S4
HEAT AND MELT METAL
S5
ROTATE HIGH PRESSURE VESSEL BY 180°
S6
PRESSURIZE INTERIOR OF HIGH PRESSURE VESSEL (IMPREGNATION TREATMENT)
S7
ROTATE HIGH PRESSURE VESSEL BY 180°
S8
INTRODUCE COOLING GAS INTO HIGH PRESSURE VESSEL
S9
MAKE CONTACT WITH CHILL BLOCK
S10

FIG. 4

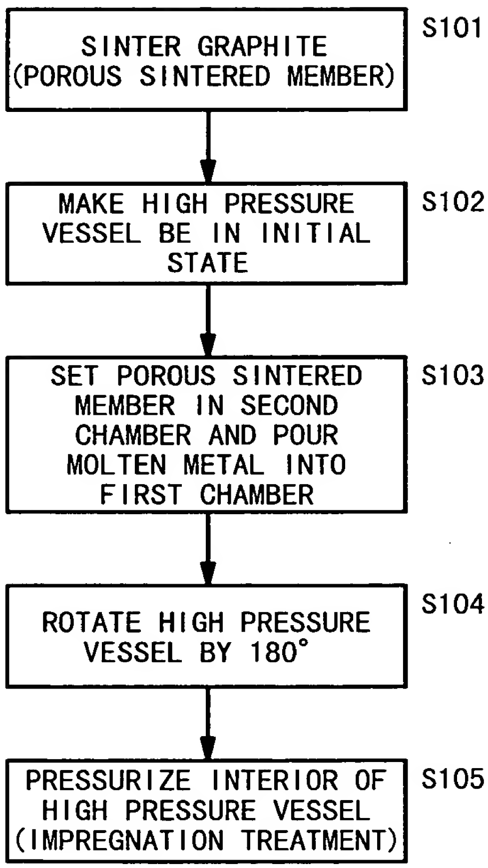

SINTER GRAPHITE (POROUS SINTERED MEMBER)
S101
MAKE HIGH PRESSURE VESSEL BE IN INITIAL STATE
S102
SET POROUS SINTERED MEMBER IN SECOND CHAMBER AND POUR MOLTEN METAL INTO FIRST CHAMBER
S103
ROTATE HIGH PRESSURE VESSEL BY 180°
S104
PRESSURIZE INTERIOR OF HIGH PRESSURE VESSEL (IMPREGNATION TREATMENT)
S105

FIG. 5

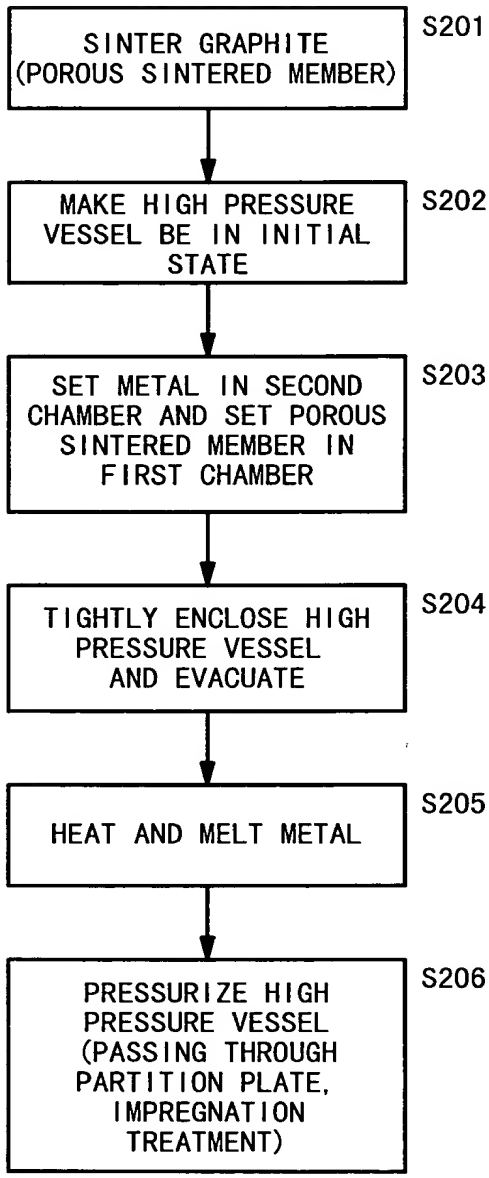

SINTER GRAPHITE (POROUS SINTERED MEMBER)
S201
MAKE HIGH PRESSURE VESSEL BE IN INITIAL STATE
S202
SET METAL IN SECOND CHAMBER AND SET POROUS SINTERED MEMBER IN FIRST CHAMBER
S203
TIGHTLY ENCLOSE HIGH PRESSURE VESSEL AND EVACUATE
S204
HEAT AND MELT METAL
S205
PRESSURIZE HIGH PRESSURE VESSEL (PASSING THROUGH PARTITION PLATE, IMPREGNATION TREATMENT)
S206

FIG. 6

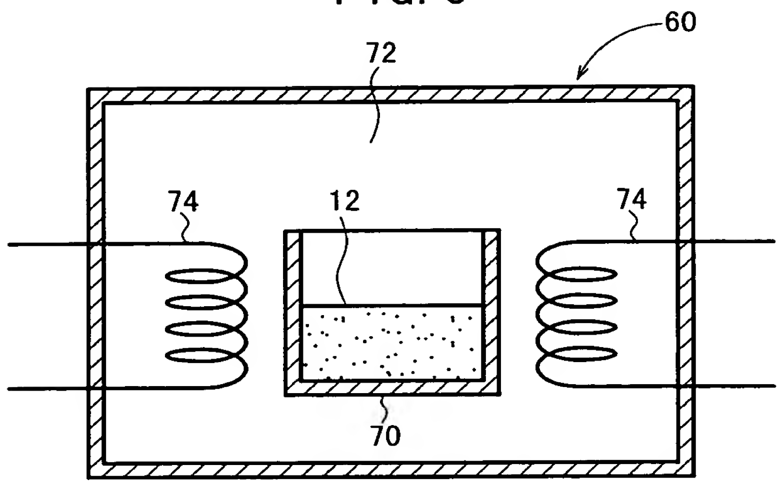


FIG. 7

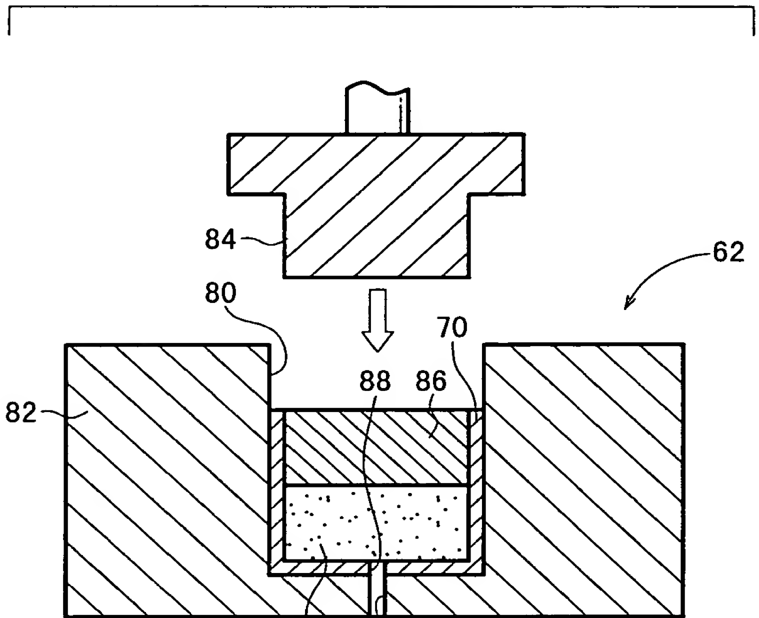


FIG. 8

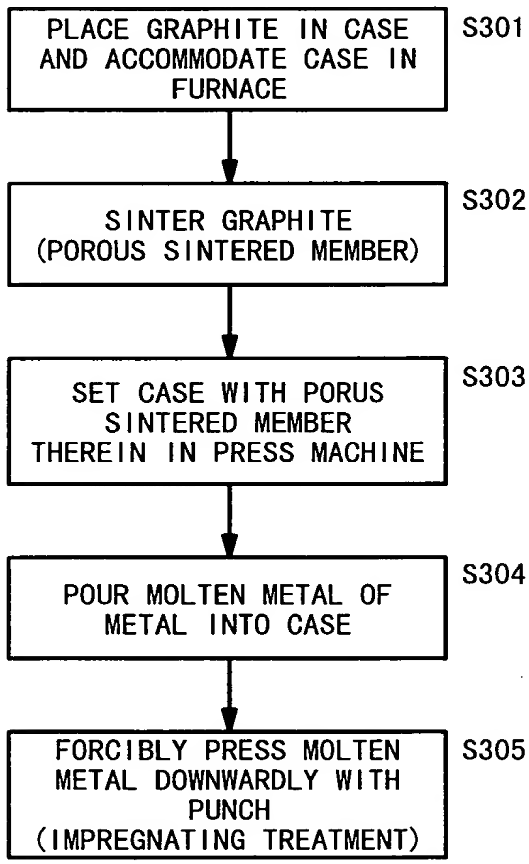

PLACE GRAPHITE IN CASE AND ACCOMMODATE CASE IN FURNACE
S301
SINTER GRAPHITE (POROUS SINTERED MEMBER)
S302
SET CASE WITH PORUS SINTERED MEMBER THEREIN IN PRESS MACHINE
S303
POUR MOLTEN METAL OF METAL INTO CASE
S304
FORCIBLY PRESS MOLTEN METAL DOWNWARDLY WITH PUNCH (IMPREGNATING TREATMENT)
S305

FIG. 9

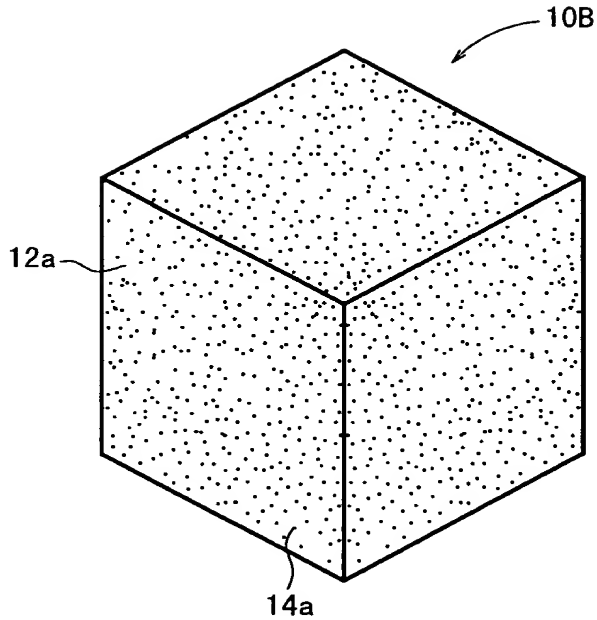


FIG. 10

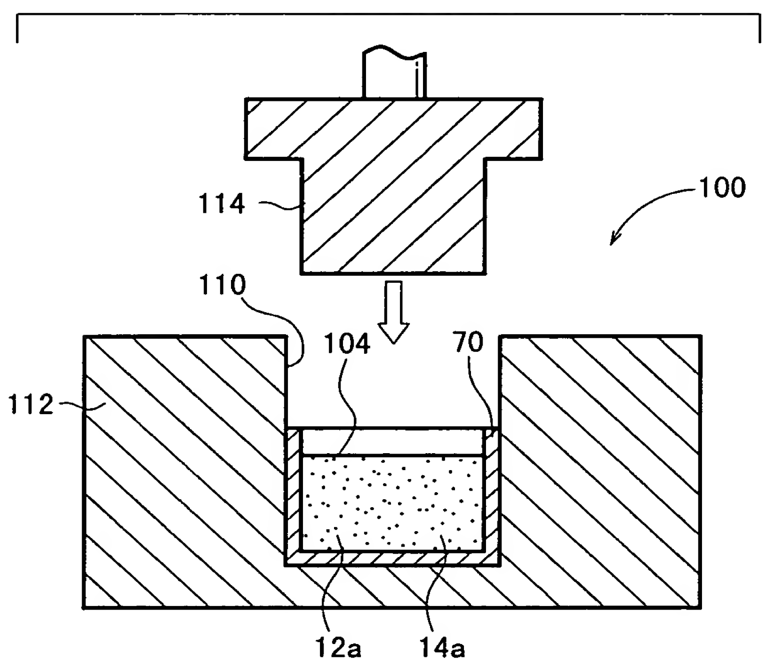


FIG. 11

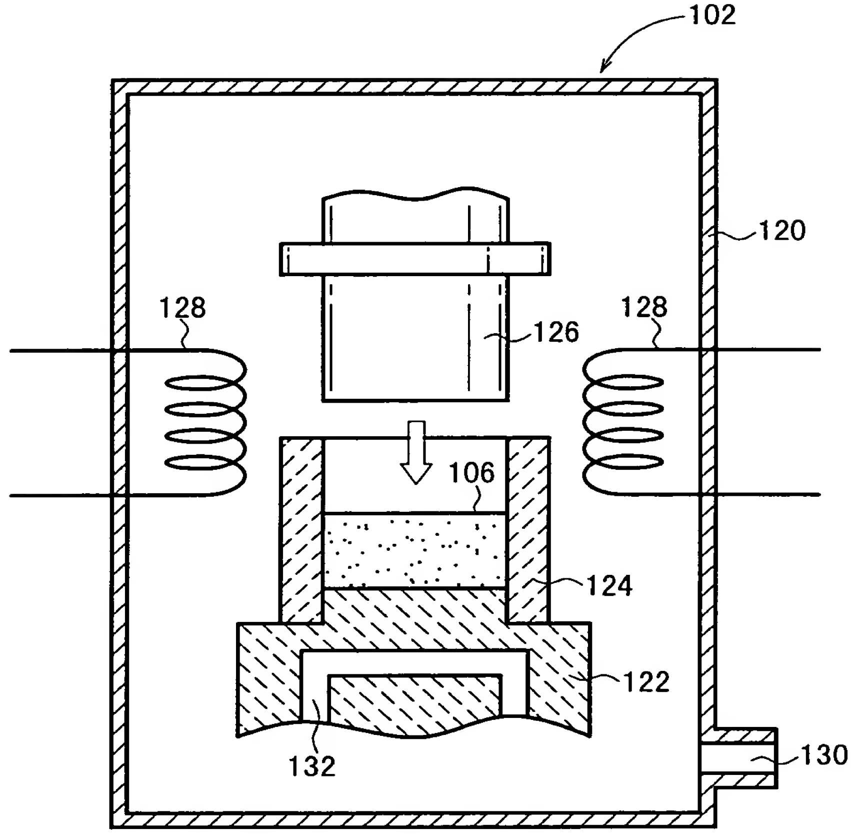


FIG. 12

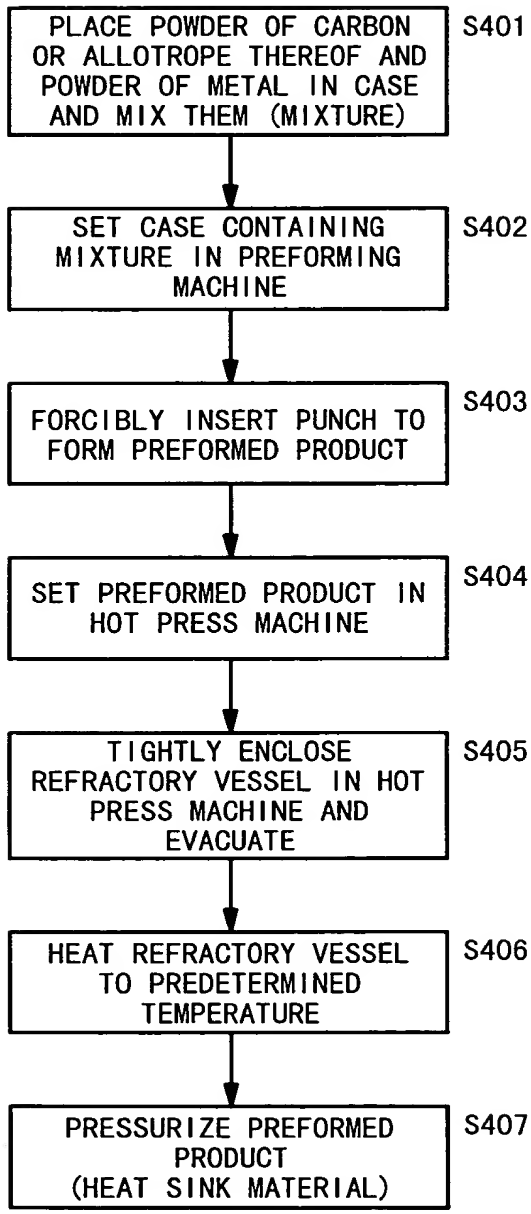

PLACE POWDER OF CARBON OR ALLOTROPE THEREOF AND POWDER OF METAL IN CASE AND MIX THEM (MIXTURE)
S401
SET CASE CONTAINING MIXTURE IN PREFORMING MACHINE
S402
FORCIBLY INSERT PUNCH TO FORM PREFORMED PRODUCT
S403
SET PREFORMED PRODUCT IN HOT PRESS MACHINE
S404
TIGHTLY ENCLOSE REFRACTORY VESSEL IN HOT PRESS MACHINE AND EVACUATE
S405
HEAT REFRACTORY VESSEL TO PREDETERMINED TEMPERATURE
S406
PRESSURIZE PREFORMED PRODUCT (HEAT SINK MATERIAL)
S407

FIG. 13

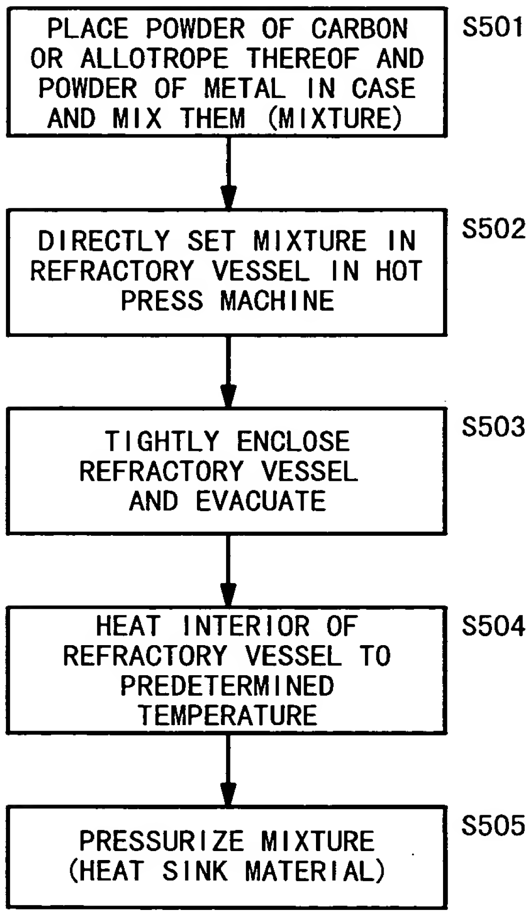

PLACE POWDER OF CARBON OR ALLOTROPE THEREOF AND POWDER OF METAL IN CASE AND MIX THEM (MIXTURE)
S501
DIRECTLY SET MIXTURE IN REFRACTORY VESSEL IN HOT PRESS MACHINE
S502
TIGHTLY ENCLOSE REFRACTORY VESSEL AND EVACUATE
S503
HEAT INTERIOR OF REFRACTORY VESSEL TO PREDETERMINED TEMPERATURE
S504
PRESSURIZE MIXTURE (HEAT SINK MATERIAL)
S505

FIG. 14

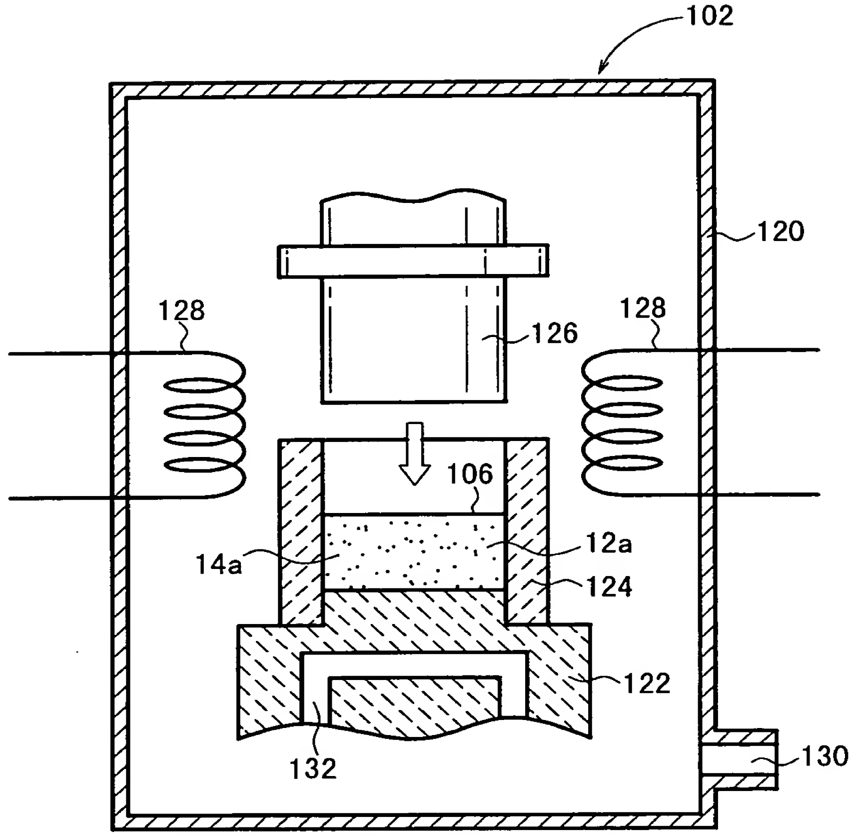


FIG. 15

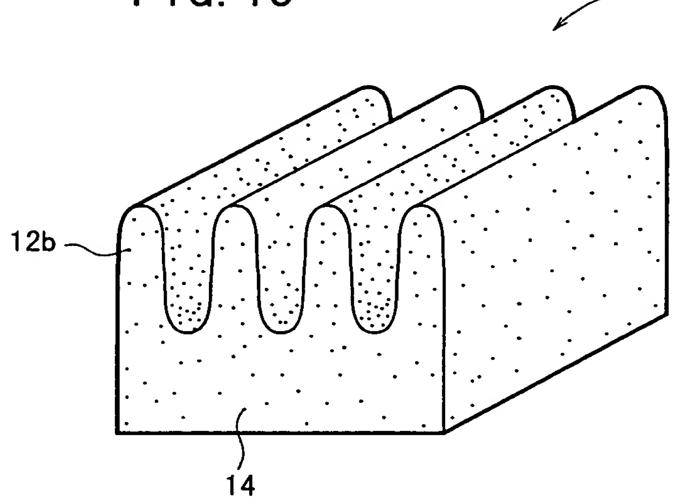


FIG. 16

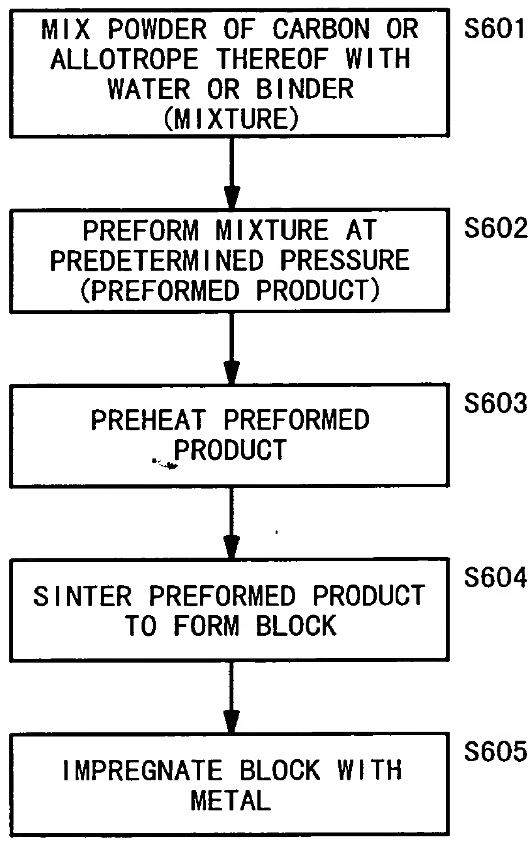

MIX POWDER OF CARBON OR ALLOTROPE THEREOF WITH WATER OR BINDER (MIXTURE)
S601
PREFORM MIXTURE AT PREDETERMINED PRESSURE (PREFORMED PRODUCT)
S602
PREHEAT PREFORMED PRODUCT
S603
SINTER PREFORMED PRODUCT TO FORM BLOCK
S604
IMPREGNATE BLOCK WITH METAL
S605

FIG. 17

SAMPLE	SIZE (mm)	TYPE OF POWDER	PARTICLE SIZE OF POWDER (μm)	FILLING METHOD	METAL	ADDED ELEMENT	AMOUNT OF ADDITION (wt%)	IMPREG-NATION METHOD	IMPREG-NATION PRESSURE (MPa)	COEFFICIENT OF THERMAL CONDUCTIVITY (W/mK)	COEFFICIENT OF THERMAL EXPANSION ($\times 10^{-6}$/K)	WATER RESISTANCE	EFFECT
PW-1	30 ×120 ×190	type -P	AVERAGE 120	NO PRESSUR-IZATION	Cu	Nb	0.001	PRESS	60.0	321	14.0	△	GENERA-TION OF CARBIDE
PW-2	30 ×120 ×191	type -S	AVERAGE 50	NO PRESSUR-IZATION	Cu	Nb	0.001	PRESS	60.0	325	13.5	△	GENERA-TION OF CARBIDE
PW-3	30 ×120 ×192	type -R	212-1180	NO PRESSUR-IZATION	Cu	Nb	0.001	PRESS	60.0	305	13.6	△	GENERA-TION OF CARBIDE
PW-4	30 ×120 ×193	type -P	AVERAGE 120	NO PRESSUR-IZATION	Cu	Nb	0.001	PRESS	60.0	321	14.0	△	GENERA-TION OF CARBIDE
PW-5	30 ×120 ×194	type -P	AVERAGE 120	PRESSUR-IZATION, 7MPa	Cu	Nb	0.001	PRESS	60.0	311	11.5	△	GENERA-TION OF CARBIDE
PW-6	30 ×120 ×195	type -P	AVERAGE 120	PRESSUR-IZATION, 25MPa	Cu	Nb	1.001	PRESS	60.0	301	9.5	△	GENERA-TION OF CARBIDE

FIG. 18

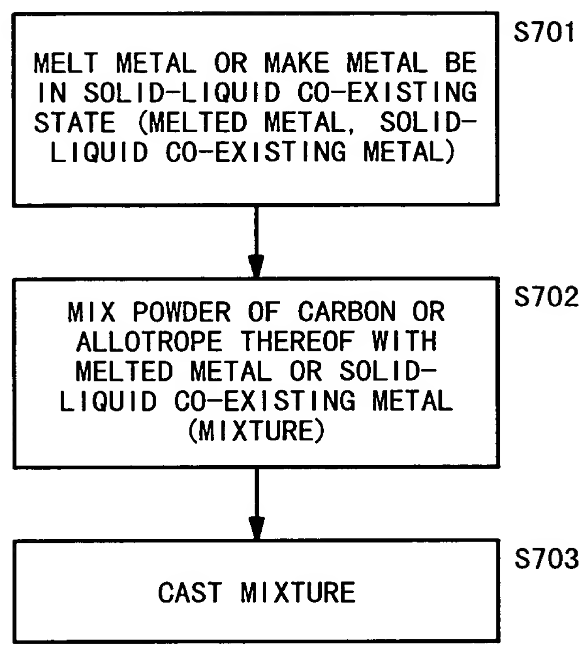

S701
MELT METAL OR MAKE METAL BE IN SOLID-LIQUID CO-EXISTING STATE (MELTED METAL, SOLID-LIQUID CO-EXISTING METAL)
S702
MIX POWDER OF CARBON OR ALLOTROPE THEREOF WITH MELTED METAL OR SOLID-LIQUID CO-EXISTING METAL (MIXTURE)
S703
CAST MIXTURE

FIG. 19

SAMPLE	SIZE (mm)	METAL	ELEMENT	AMOUNT OF ADDITION (wt%)	IMPREG-NATING METHOD	COEFFICIENT OF THERMAL CONDUCTIVITY (W/mK)		COEFFICIENT OF THERMAL EXPANSION ($\times 10^{-6}$/°C)		BENDING STRENGTH (MPa)		WATER RESISTANCE	EFFECT
						SUR-FACE	THICK-NESS	SUR-FACE	THICK-NESS	SUR-FACE	THICK-NESS		
p1-1	20x60x60	Al	NONE	NONE	PRESS	171	171	5.3	5.5	33.3	53.9	△	NONE
p1-2	20x60x60	Cu	NONE	NONE	PRESS	162	170	5.1	5.1	27.4	41.2	◎	NONE
p2-1	20x60x60	Cu	Bi	2	PRESS	168	178	5.0	5.1	28.4	45.1	◎	WETT-ABILITY
p2-2	20x60x60	Cu	Sb	0.5		178	186	5.0	5.1	27.4	41.2		
p2-3	20x60x60	Cu	Te	0.5		180	189	5.0	5.1	26.5	39.2		
p2-4	20x60x60	Cu	Te	2		172	178	4.9	5.0	25.5	38.2		
p2-5	20x60x60	Cu	Te, Bi	0.5, 0.5		169	176	5.0	5.0	26.5	39.2		
p2-6	20x60x60	Cu	Te, Pb	0.5, 2.0		172	185	5.0	5.0	27.4	41.2		
p3-1	20x60x60	Cu	Be	1	PRESS	184	204	5.0	5.0	34.3	57.8	△	GENERATION OF CARBIDE
p3-2	20x60x60	Cu	Cr	0.5		187	192	5.0	5.0	37.2	58.8		
p3-3	20x60x60	Cu	Mn	0.5		175	181	5.0	5.0	34.3	56.8		
p3-4	20x60x60	Cu	Nb	0.05		187	190	5.0	5.0	34.3	56.8		
p3-5	20x60x60	Cu	Zr	0.5		172	174	5.0	5.0	24.5	40.2		
p4-1	20x60x60	Cu	Te, Ni	0.5, 0.5	PRESS	165	177	5.0	5.0	27.4	45.1	○	COMBINED ADDITION
p5-1	20x60x60	Cu	NONE	NONE	GAS	170	188	5.0	5.0	27.4	41.2	◎	NONE
p6-1	10x85x180	Cu	Te	2	GAS	185	196	5.0	5.1	26.5	39.2	◎	WETT-ABILITY
p6-2	20x60x60	Cu	Te	2		192	204	5.0	5.0	28.4	42.1		

FIG. 20

SAMPLE	SIZE (mm)	METAL	ELEMENT	AMOUNT OF ADDITION (wt%)	IMPREG-NATING METHOD	COEFFICIENT OF THERMAL CONDUCTIVITY (W/mK)		COEFFICIENT OF THERMAL EXPANSION ($\times 10^{-6}$/°C)		BENDING STRENGTH (MPa)		WATER RESISTANCE	EFFECT
						SUR-FACE	THICK-NESS	SUR-FACE	THICK-NESS	SUR-FACE	THICK-NESS		
m1-1	20x60x60	Al	NONE	NONE	PRESS	161	187	4.5	5.6	34.3	56.8	△	NONE
m1-2	20x60x60	Cu	NONE	NONE	PRESS	145	181	4.5	5.1	28.4	42.1	◎	NONE
m2-1	20x60x60	Cu	Te	0.50	PRESS	168	199	4.5	5.1	26.5	39.2	◎	WETT-ABILITY
m3-1	20x60x60	Cu	Be	1.00	PRESS	184	213	4.5	5.1	36.3	59.8	△	GENERATION OF CARBIDE
m3-2	20x60x60	Cu	Cr	0.50		170	193	4.5	5.1	37.2	60.8		
m3-3	20x60x60	Cu	Mn	0.50		165	192	4.5	5.1	35.3	57.8		
m3-4	20x120x190	Cu	Nb	0.05		162	192	4.5	5.1	35.3	57.8		
m3-5	20x60x60	Cu	Nb	0.05		169	207	4.5	5.1	35.3	57.8		
m3-6	20x60x60	Cu	Zr	0.50		158	182	4.5	5.1	32.3	52.9		
m5-1	20x60x60	Cu	NONE	NONE	GAS	166	198	4.5	5.1	25.5	38.2	◎	NONE

FIG. 21

SAMPLE	SIZE (mm)	METAL	ADDITIVE ELEMENT	AMOUNT OF ADDITION (wt%)	IMPREGNATING METHOD	IMPREGNATION PRESSURE (MPa)	COEFFICIENT OF THERMAL CONDUCTIVITY (W/mK)		COEFFICIENT OF THERMAL EXPANSION ($\times 10^{-6}$/K)		BENDING STRENGTH (MPa)		COMPRESSIVE STRENGTH (MPa)		WATER RESISTANCE	EFFECT
									SUR-FACE	THICK-NESS	SUR-FACE	THICK-NESS	SUR-FACE	THICK-NESS		
n1-1	20×60×60	Al	NONE	NONE	PRESS	26.7	156	311	5.5	6.0	31.4	51.9	46.1	51.0	△	NONE
n1-4	20×120×190	Al	NONE	NONE	PRESS	60.0	185	350	5.5	6.5					△	NONE
n1-2	20×60×60	Cu	NONE	NONE	PRESS	26.7	150	310	3.8	4.5	26.5	39.2			◎	NONE
n1-3	20×120×190	Cu	NONE	NONE	PRESS	26.7	147	268	3.9	4.5	26.5	39.2			◎	NONE
n2-1	20×60×60	Cu	Te	0.500	PRESS	26.7	190	351	3.8	4.5	26.5	39.2			◎	WETTABILITY
n3-1	20×60×60	Cu	Be	1.000	PRESS	26.7	183	341	3.8	4.5	38.2	62.7			△	GENERATION OF CARBIDE
n3-2	20×120×190	Cu	Be	1.000	PRESS	156.1	189	342	4.0	4.6	37.2	61.7			△	
n3-3	20×60×60	Cu	Cr	0.500	PRESS	26.7	180	320	3.8	4.5	36.3	59.8			△	
n3-4	20×60×60	Cu	Mn	0.500	PRESS	26.7	176	330	3.8	4.5	34.3	55.9	42.1	48.0	△	
n3-5	20×60×60	Cu	Nb	0.050	PRESS	156.1	198	336	3.8	4.5	35.3	57.8			△	
n3-6	20×120×190	Cu	Nb	0.050	PRESS	26.7	167	309	3.8	4.5	35.3	57.8			△	
n3-7	20×60×60	Cu	Zr	0.500	PRESS	26.7	158	312	3.8	4.5	34.3	56.8			△	
n3-8	20×120×190	Cu	Nb	0.001	PRESS	43.3	182	352	4.5	3.0			40.2	51.9	△	
n3-9	20×120×190	Cu	Nb	0.001	PRESS	60.0	182	363	4.0	3.0			42.1	51.9	△	
n3-10	20×120×190	Cu	Nb	1.100	PRESS	60.0	196	359	4.0	2.5			51.0	58.8	△	
n3-11	20×120×190	Cu	Be	1.900	PRESS	60.0	186	366	4.5	3.5			57.8	64.7	△	
n3-12	20×120×190	Cu	Ni, Sn	9.4, 6.7	PRESS	60.0	190	343					51.9	51.0	◎	COMBINED ADDITION
n3-13	20×120×190	Cu	Ni, Si, P	1.0, 0.23, 0.04		60.0	190	353					48.0	51.9	○	
n3-14	20×120×190	Cu	Mn	4.180	PRESS	60.0	181	352					51.0	54.9	△	GENERATION OF CARBIDE
n3-15	20×120×190	Cu	Cr	2.870	PRESS	60.0	195	387					48.0	51.9	△	
n3-16	20×120×190	Cu	Zr	4.490	PRESS	60.0	207	367					53.9	63.7	△	
n3-17	20×120×190	Cu	Si	11.300	PRESS	26.7	157	333					53.9	60.8	◎	EXPANSION OF SOLID-LIQUID RANGE
n3-18	20×120×190	Cu	Si	10.900	PRESS	60.0	159	316					56.8	68.6	◎	
n3-19	20×120×190	Cu	Si	5.170	PRESS	153.0	165	343					52.9	62.7	◎	
n3-20	20×120×190	Cu	Si	5.300	PRESS	43.3	163	325					54.9	60.8	◎	
n5-1	20×60×60	Cu	NONE	NONE	GAS	26.7	170	320	3.8	4.5	26.5	39.2			◎	NONE
n7-1	20×120×190	Al	Be	2.000	PRESS	60.0	177	332	5.0	6.5			57.8	62.7	△	GENERATION OF CARBIDE
n7-2	20×120×190	Al	Si	5.000	PRESS	60.0	169	329	5.0	6.5			50.0	61.7	◎	EXPANSION OF SOLID-LIQUID RANGE
n7-3	20×120×190	Al	Si	12.000	PRESS	60.0	181	327	5.0	6.5			56.8	68.6	◎	

FIG. 22

TYPE OF CARBON	COEFFICIENT OF THERMAL CONDUCTIVITY (W/mK)		COEFFICIENT OF THERMAL EXPANSION ($\times 10^{-6}$/°C)		BENDING STRENGTH (MPa)	
	SURFACE DIRECTION	THICKNESS DIRECTION	SURFACE DIRECTION	THICKNESS DIRECTION	SURFACE DIRECTION	THICKNESS DIRECTION
P	150	160	3.2	3.2	34.3	49.0
M	140	168	3.2	3.2	29.4	44.1
N	150	255	1.8	2.3	14.7	29.4

FIG. 23

SAMPLE	SIZE (mm)	METAL	ELEMENT	AMOUNT OF ADDITION (wt%)	IMPREG-NATING METHOD	COEFFICIENT OF THERMAL CONDUCTIVITY (W/mK)		COEFFICIENT OF THERMAL EXPANSION ($\times 10^{-6}$/°C)		BENDING STRENGTH (MPa)		WATER RESISTANCE	EFFECT
						SUR-FACE	THICK-NESS	SUR-FACE	THICK-NESS	SUR-FACE	THICK-NESS		
p1-2	20x60x60	Cu	NONE	NONE	PRESS	162	170	5.1	5.1	27.4	41.2	◎	NONE
p5-1	20x60x60				GAS	170	188	5.0	5.0	27.4	41.2		
p2-4	20x60x60	Cu	Te	2	PRESS	172	178	4.9	5.0	25.5	38.2	◎	WETT-ABILITY
p6-2	20x60x60	Cu	Te	2	GAS	192	204	5.0	5.0	28.4	42.1		
m1-2	20x60x60	Cu	NONE	NONE	PRESS	145	181	4.5	5.1	28.4	42.1	◎	NONE
m5-1	20x60x60				GAS	166	198	4.5	5.1	25.5	38.2		
n1-2	20x60x60	Cu	NONE	NONE	PRESS	150	310	3.8	4.5	26.5	39.2	◎	NONE
n5-1	20x60x60	Cu			GAS	170	320	3.8	4.5	26.5	39.2		

FIG. 24

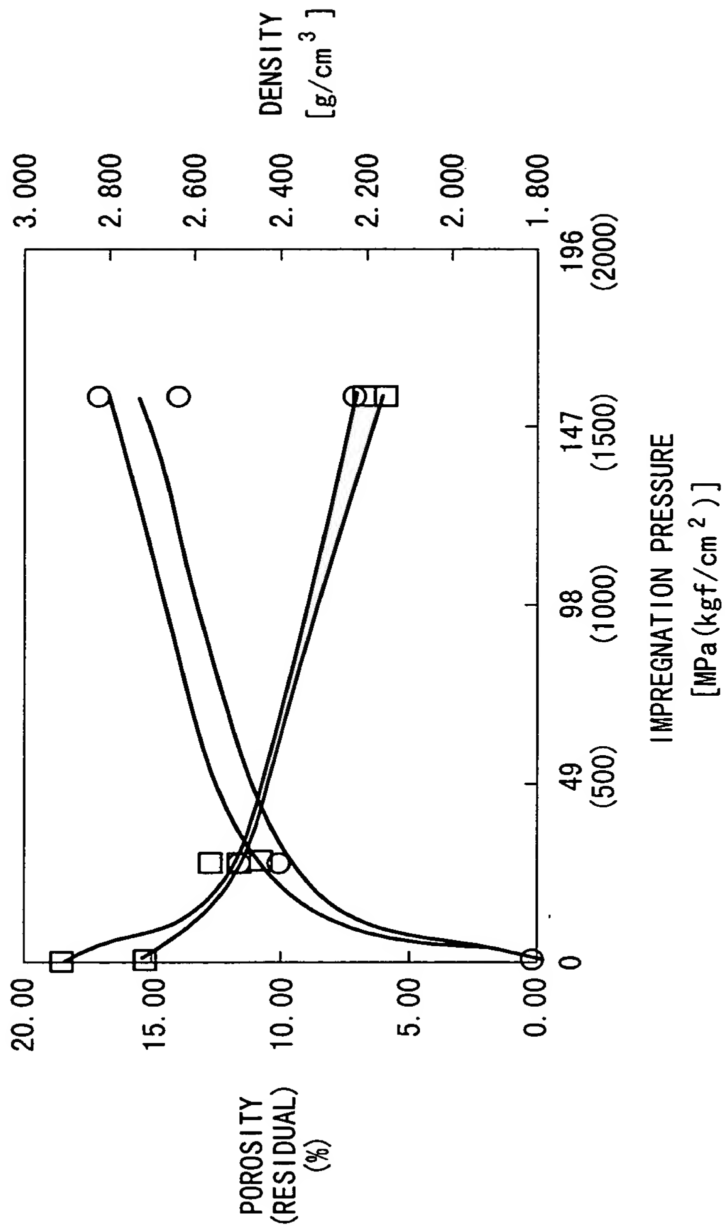

DENSITY
[g/cm^3]
3.000
2.800
2.600
2.400
2.200
2.000
1.800
196
(2000)
147
(1500)
98
(1000)
49
(500)
0
IMPREGNATION PRESSURE
[MPa(kgf/cm^2)]
20.00
15.00
10.00
5.00
0.00
POROSITY
(RESIDUAL)
(%)

FIG. 25

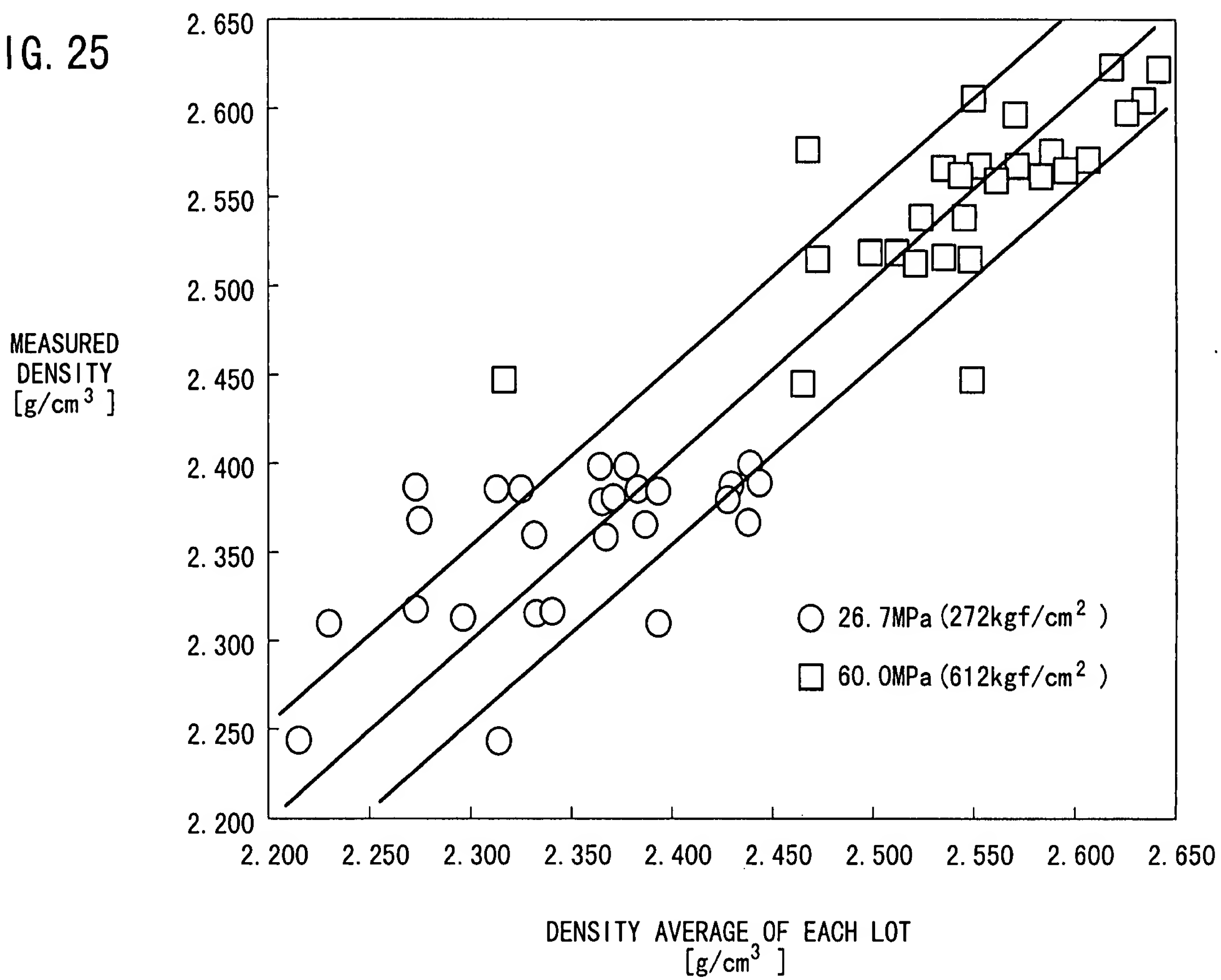

MEASURED
DENSITY
[g/cm3]
2.650
2.600
2.550
2.500
2.450
2.400
2.350
2.300
2.250
2.200
2.200
2.250
2.300
2.350
2.400
2.450
2.500
2.550
2.600
2.650
26.7MPa (272kgf/cm2)
60.0MPa (612kgf/cm2)
DENSITY AVERAGE OF EACH LOT
[g/cm3]

FIG. 26

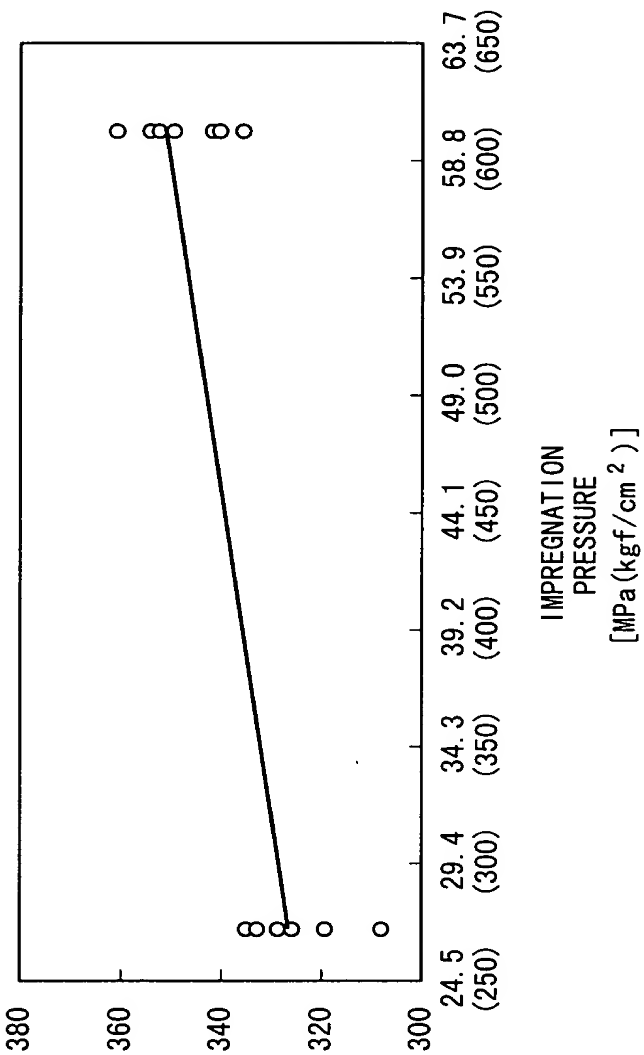

COEFFICIENT OF THERMAL CONDUCTIVITY [W/mK]
380
360
340
320
300
24.5 (250)
29.4 (300)
34.3 (350)
39.2 (400)
44.1 (450)
49.0 (500)
53.9 (550)
58.8 (600)
63.7 (650)
IMPREGNATION PRESSURE [MPa(kgf/cm^2)]

FIG. 27

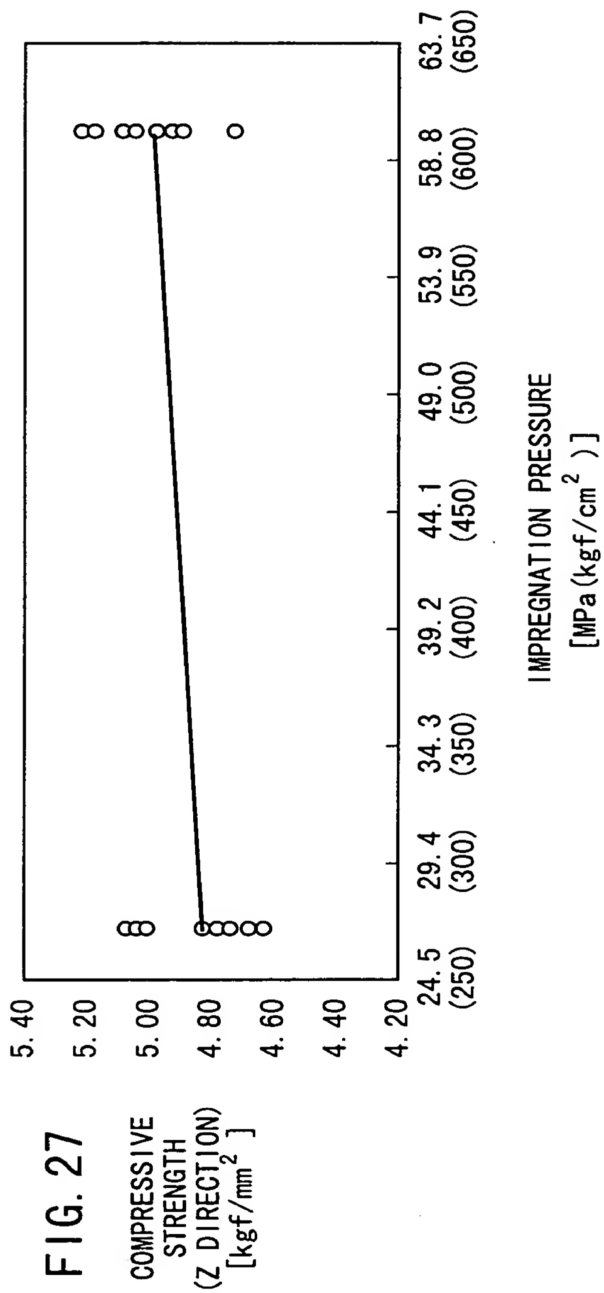

COMPRESSIVE STRENGTH (Z DIRECTION) [kgf/mm2]
5.40
5.20
5.00
4.80
4.60
4.40
4.20
24.5 (250)
29.4 (300)
34.3 (350)
39.2 (400)
44.1 (450)
49.0 (500)
53.9 (550)
58.8 (600)
63.7 (650)
IMPREGNATION PRESSURE [MPa (kgf/cm2)]

FIG. 28

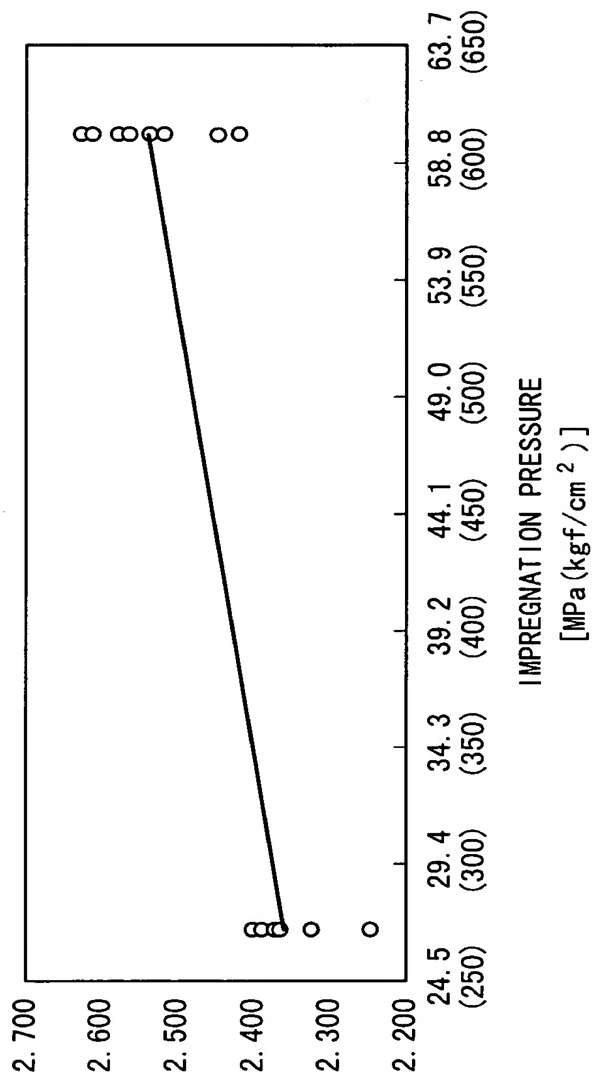

DENSITY [g/cm^3]
2.700
2.600
2.500
2.400
2.300
2.200
24.5 (250)
29.4 (300)
34.3 (350)
39.2 (400)
44.1 (450)
49.0 (500)
53.9 (550)
58.8 (600)
63.7 (650)
IMPREGNATION PRESSURE
[MPa (kgf/cm^2)]

FIG. 29

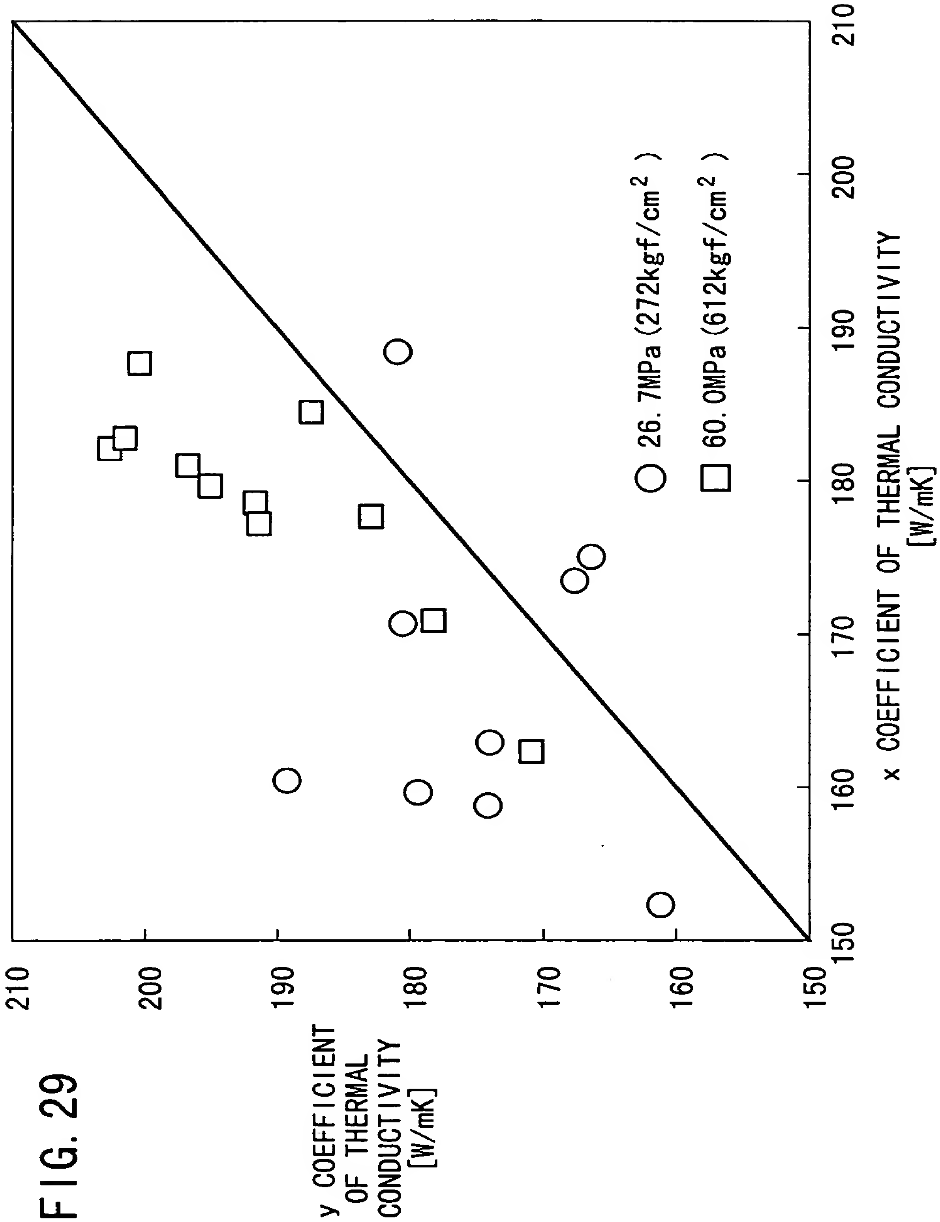

y COEFFICIENT OF THERMAL CONDUCTIVITY [W/mK]
210
200
190
180
170
160
150
150
160
170
180
190
200
210
x COEFFICIENT OF THERMAL CONDUCTIVITY [W/mK]
26.7MPa (272kgf/cm²)
60.0MPa (612kgf/cm²)

FIG. 30

No.	POROSITY [%]	PORE DIAMETER [μm]	Ni PLATING	Si IMPREG-NATION	IMPREGNATION TEMPERATURE [℃]	PRESSURIZATION [MPa (kgf/cm²)]	PRESSURIZATION TIME [sec]	COOLING SPEED [℃/min]	REACTION OF Si/Cu	IMPREG-NATION
SAMPLE1	35	70	ABSENT	ABSENT	1130	0.78 (8)	60	260	△	△
SAMPLE2	44	22	ABSENT	ABSENT	1130	7.84 (80)	20	900	○	◎
SAMPLE3	59	42	ABSENT	PRESENT	1130	11.8 (120)	10	480	◎	◎
SAMPLE4	15	5	PRESENT	ABSENT	1130	23.5 (240)	10	900	◎	○
SAMPLE5	59	42	ABSENT	PRESENT	1180	0.78 (8)	60	900	△	△
SAMPLE6	15	5	ABSENT	ABSENT	1180	3.92 (40)	20	480	○	△
SAMPLE7	59	42	ABSENT	PRESENT	1180	11.8 (120)	10	900	◎	◎
SAMPLE8	44	22	ABSENT	ABSENT	1180	23.5 (240)	10	620	◎	◎
SAMPLE9	44	22	ABSENT	PRESENT	1230	0.78 (8)	20	480	○	△
SAMPLE10	59	42	PRESENT	ABSENT	1230	3.92 (40)	35	790	○	○
SAMPLE11	35	70	ABSENT	ABSENT	1230	7.84 (80)	100	620	◎	◎
SAMPLE12	44	22	ABSENT	PRESENT	1230	23.5 (240)	5	620	◎	◎
SAMPLE13	59	42	ABSENT	ABSENT	1280	3.92 (40)	50	790	○	○
SAMPLE14	35	70	ABSENT	ABSENT	1280	7.84 (80)	35	480	△	◎
SAMPLE15	44	22	PRESENT	ABSENT	1280	7.84 (80)	5	620	○	◎
SAMPLE16	59	42	ABSENT	PRESENT	1280	11.8 (120)	10	790	○	◎
SAMPLE17	20	21	ABSENT	ABSENT	1150	156.1	3	900	◎	◎
SAMPLE18	20	19	ABSENT	ABSENT	1150	156.1	5	900	◎	◎
SAMPLE19	20	23	ABSENT	ABSENT	1140	69.3	5	900	◎	◎
SAMPLE20	20	22	ABSENT	ABSENT	1145	26.7	7	900	◎	◎

NOTES REACTION of Si/Cu: ◎NO REACTION ○SLIGHT REACTION △STRONG REACTION
IMPREGNATION OF Cu : ◎GOOD IMPREGNATION ○SLIGHTLY INSUFFICIENT IMPREGNATION
△INSUFFICIENT IMPREGNATION

09/913353

FIG. 31

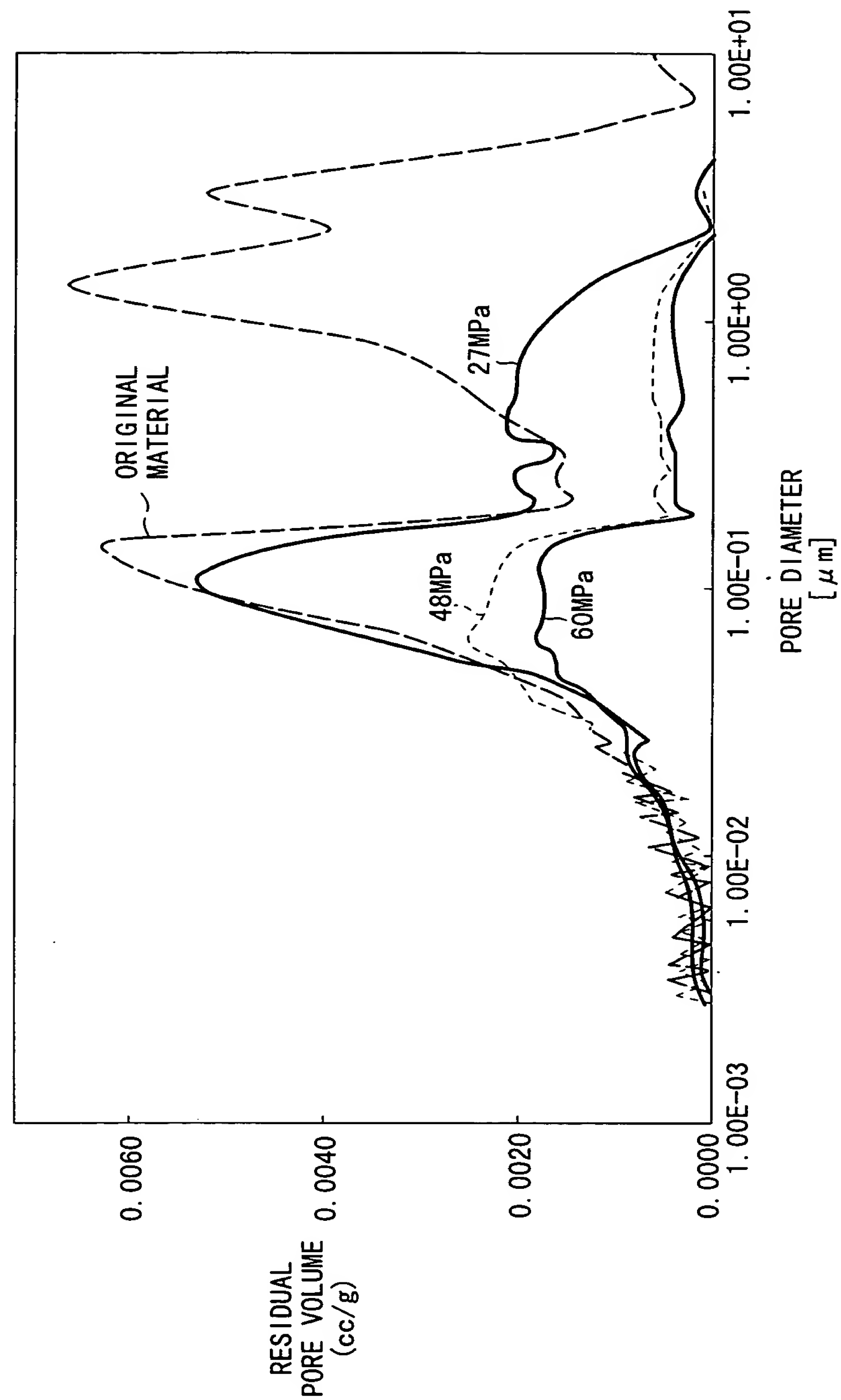


FIG. 32

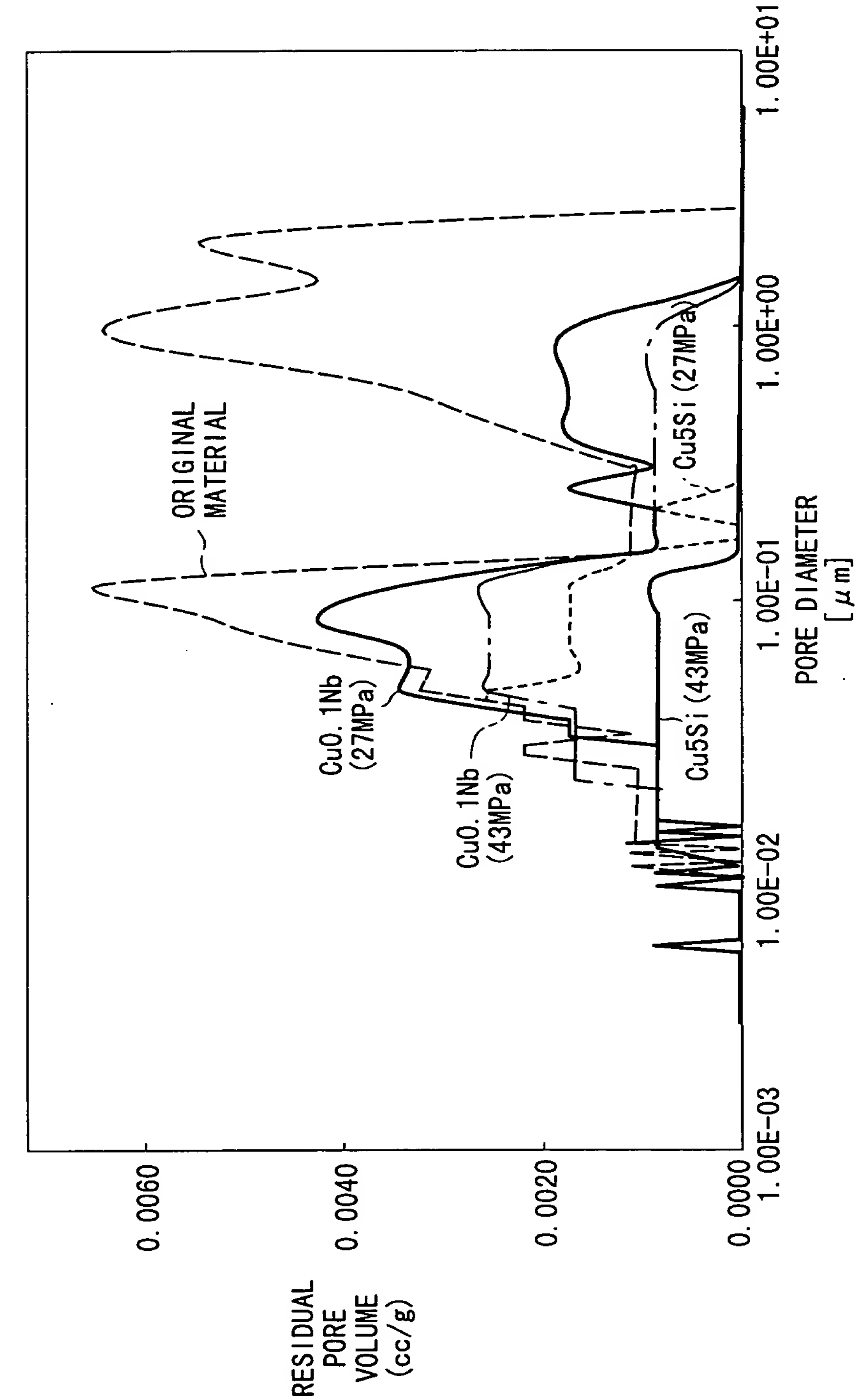

RESIDUAL PORE VOLUME (cc/g)
0.0000
0.0020
0.0040
0.0060
1.00E-03
1.00E-02
1.00E-01
1.00E+00
1.00E+01
PORE DIAMETER [μm]
ORIGINAL MATERIAL
Cu0.1Nb (27MPa)
Cu0.1Nb (43MPa)
Cu5Si (43MPa)
Cu5Si (27MPa)

FIG. 33

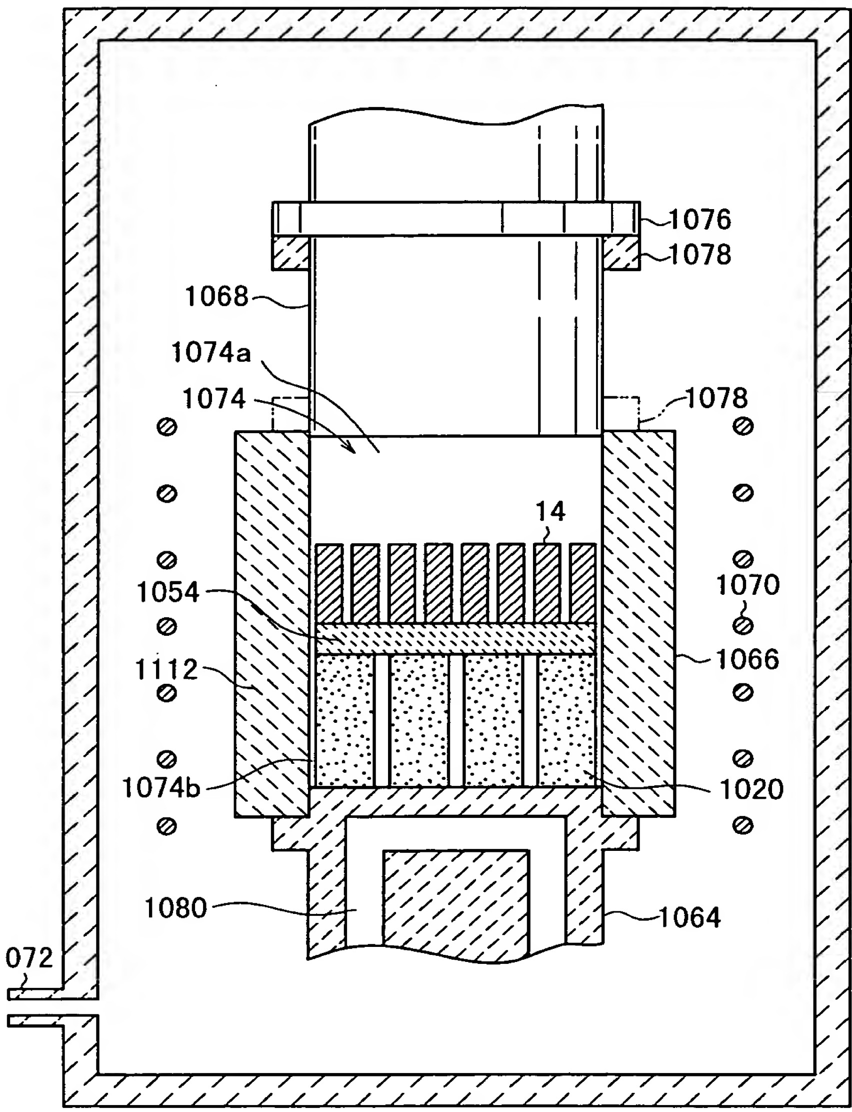

1060
1076
1078
1068
1074a
1074
1078
14
1062
1070
1054
1066
1112
1074b
1020
1080
1064
1072

FIG. 34

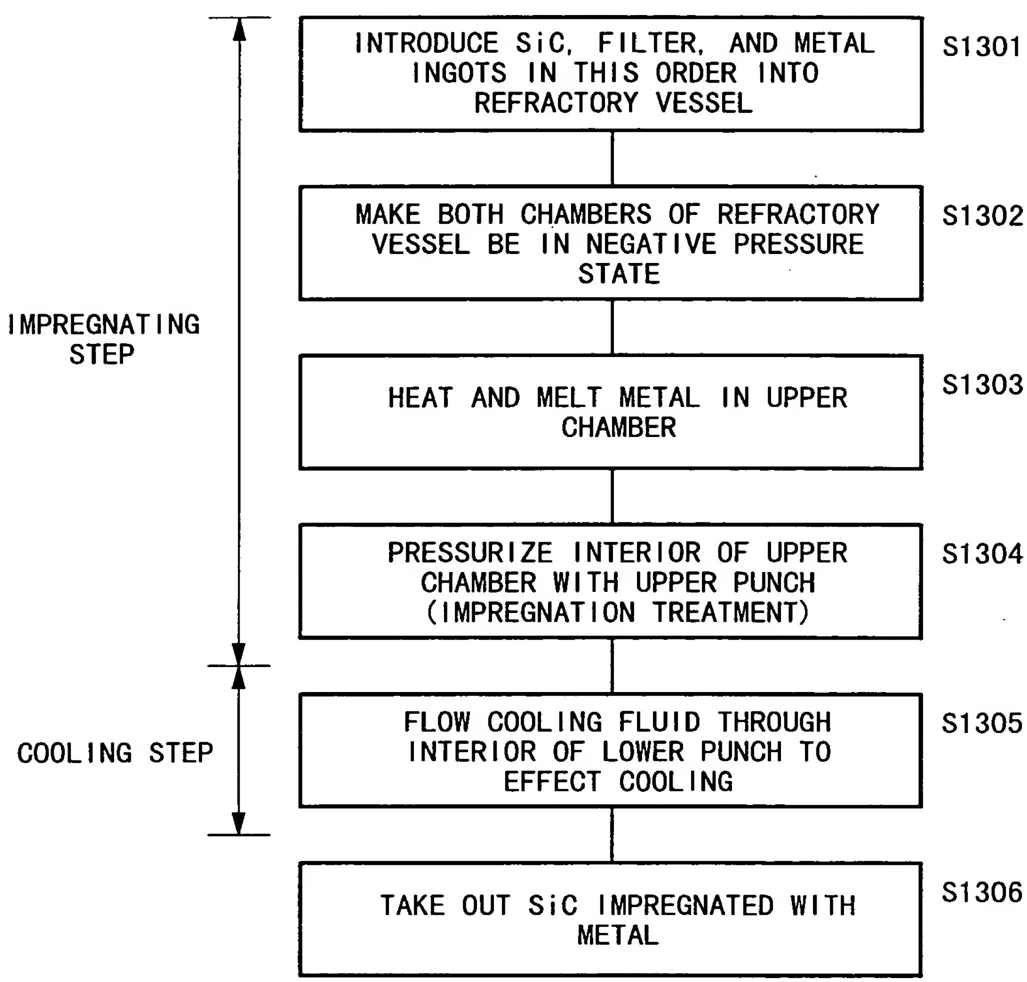

INTRODUCE SiC, FILTER, AND METAL INGOTS IN THIS ORDER INTO REFRACTORY VESSEL
S1301
MAKE BOTH CHAMBERS OF REFRACTORY VESSEL BE IN NEGATIVE PRESSURE STATE
S1302
HEAT AND MELT METAL IN UPPER CHAMBER
S1303
PRESSURIZE INTERIOR OF UPPER CHAMBER WITH UPPER PUNCH (IMPREGNATION TREATMENT)
S1304
IMPREGNATING STEP
FLOW COOLING FLUID THROUGH INTERIOR OF LOWER PUNCH TO EFFECT COOLING
S1305
COOLING STEP
TAKE OUT SiC IMPREGNATED WITH METAL
S1306

FIG. 35A

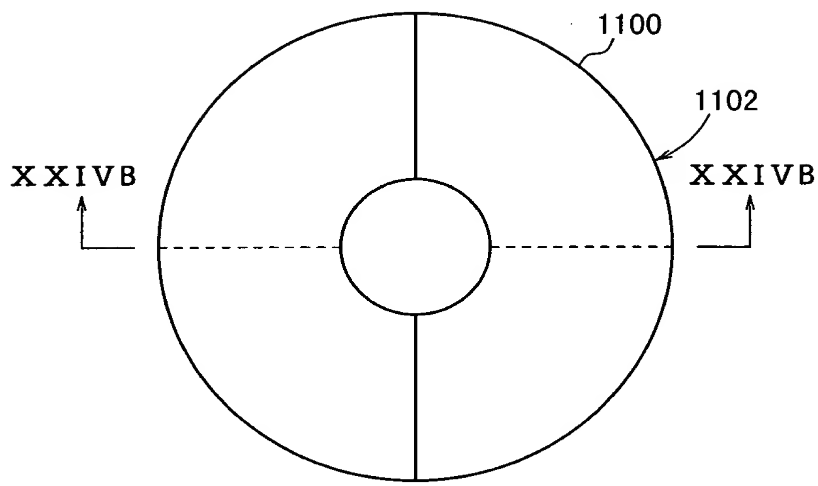


FIG. 35B

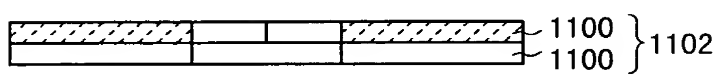


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FIG. 36

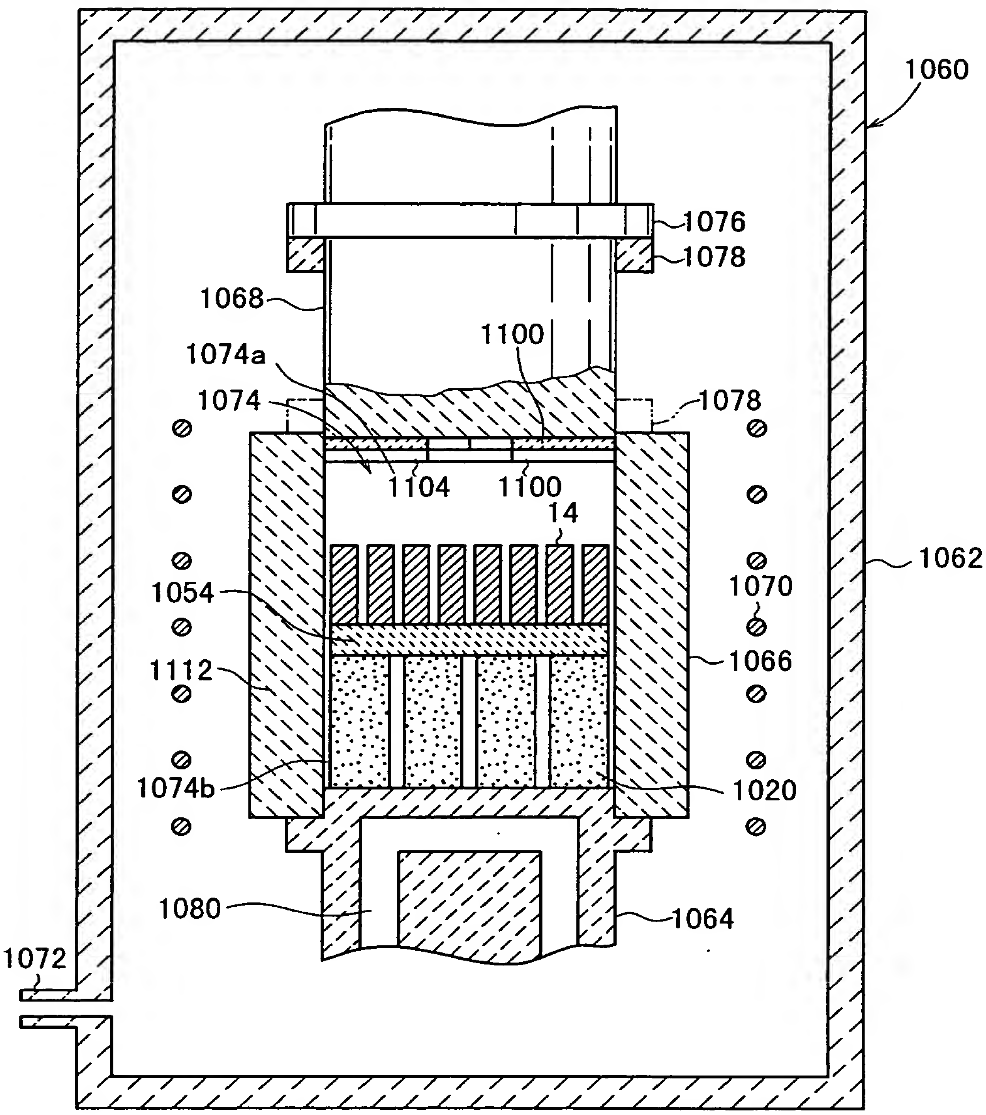


FIG. 37

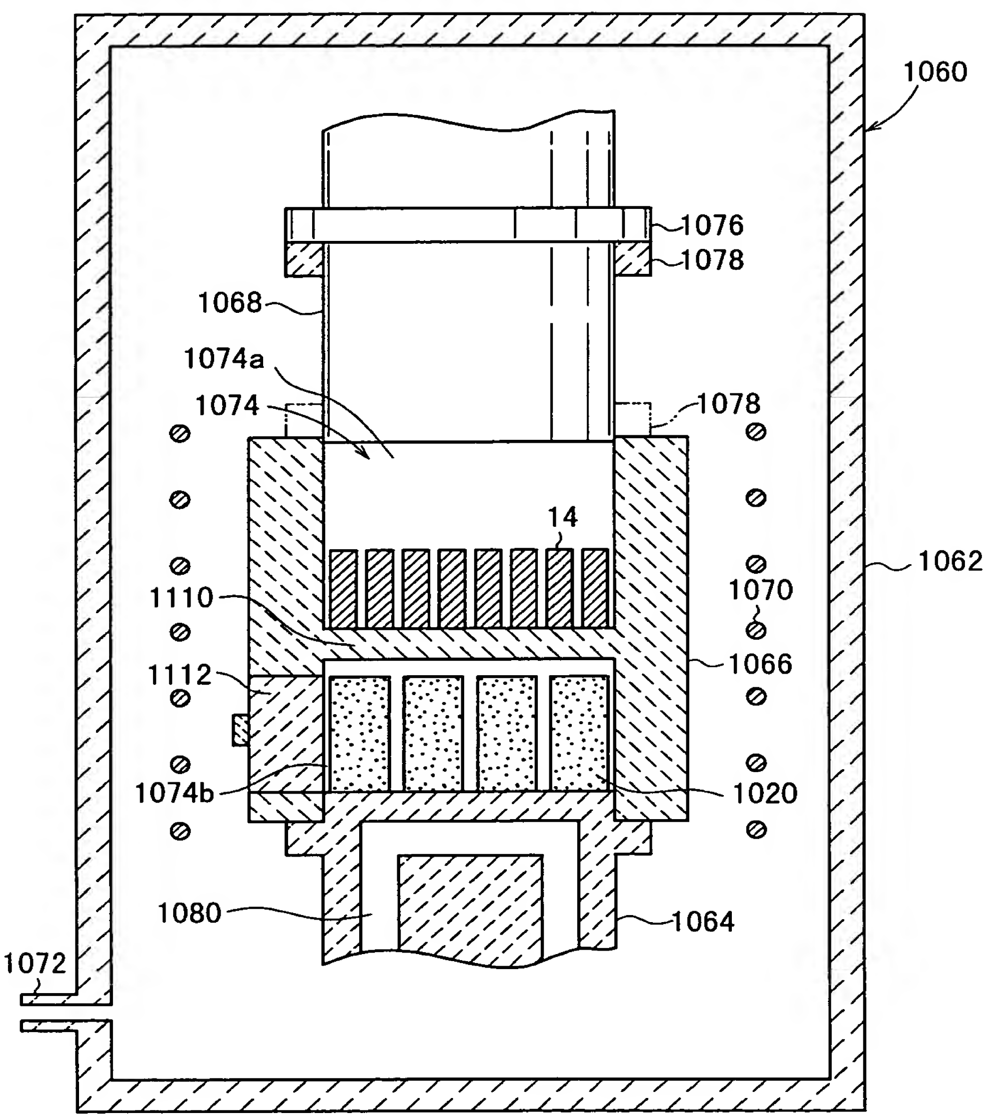

1060
1076
1078
1068
1074a
1074
1078
14
1062
1110
1070
1066
1112
1074b
1020
1080
1064
1072

FIG. 38

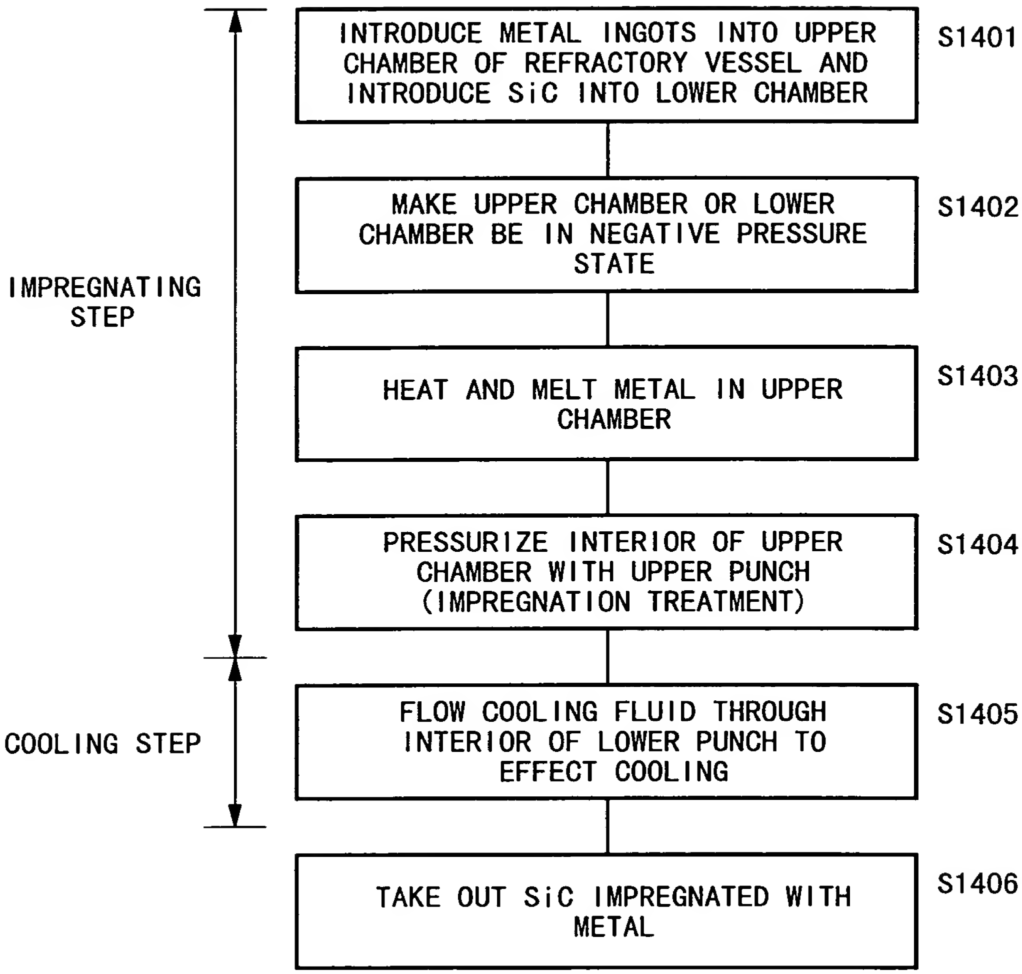
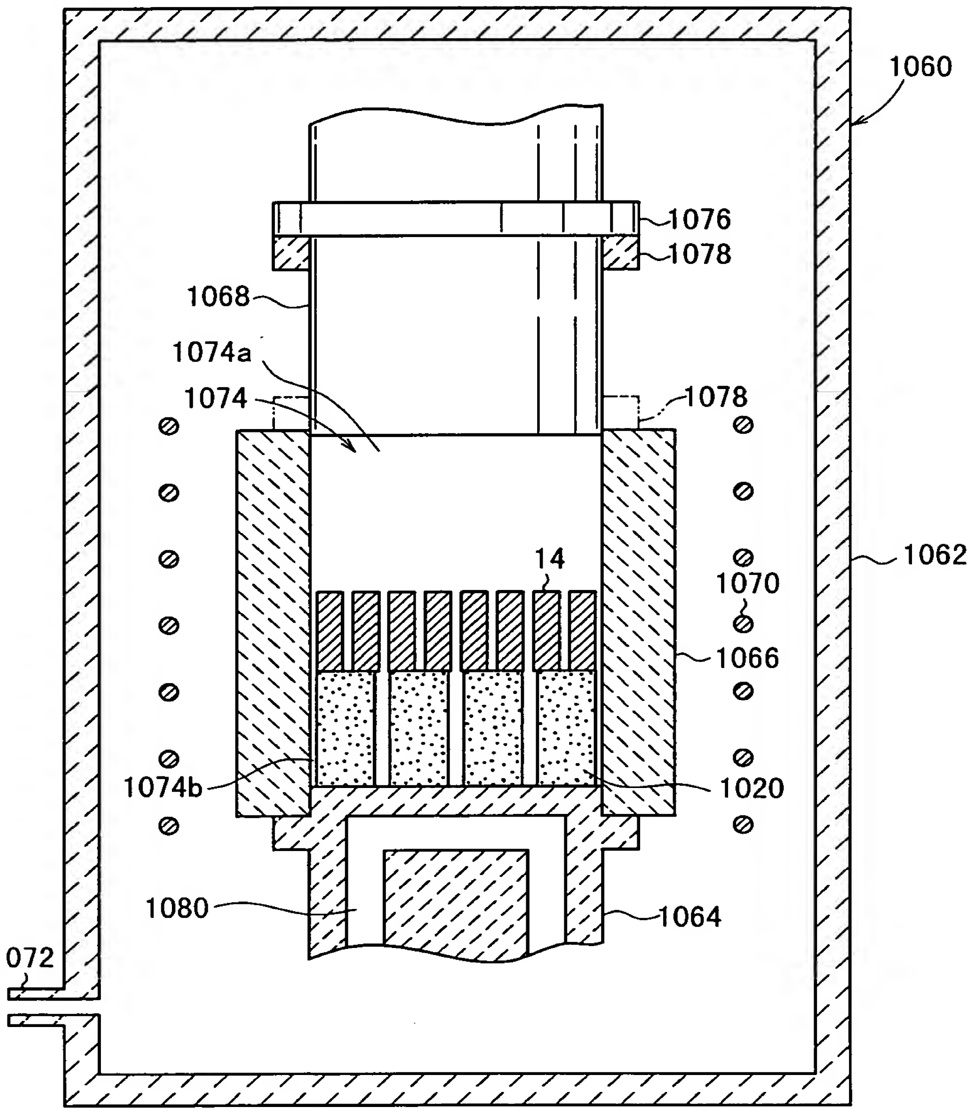
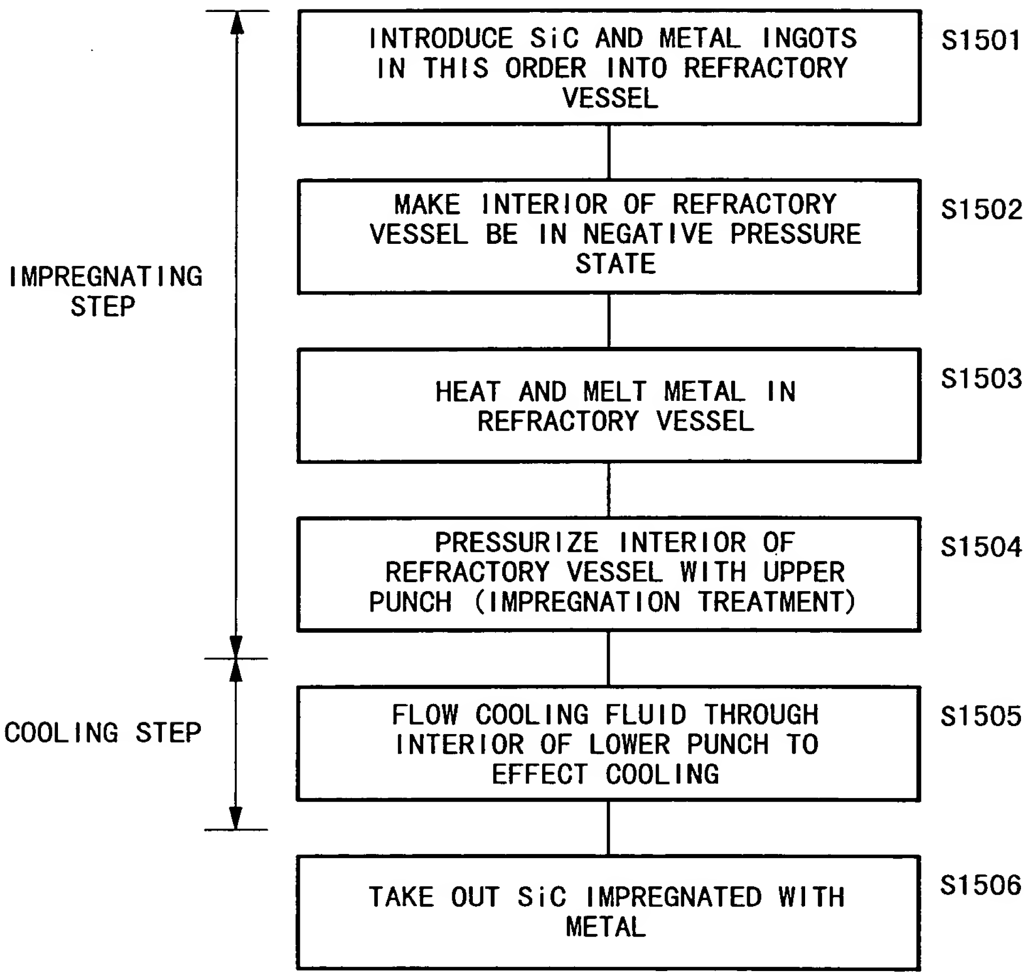

INTRODUCE METAL INGOTS INTO UPPER CHAMBER OF REFRACTORY VESSEL AND INTRODUCE SiC INTO LOWER CHAMBER
S1401
MAKE UPPER CHAMBER OR LOWER CHAMBER BE IN NEGATIVE PRESSURE STATE
S1402
HEAT AND MELT METAL IN UPPER CHAMBER
S1403
PRESSURIZE INTERIOR OF UPPER CHAMBER WITH UPPER PUNCH (IMPREGNATION TREATMENT)
S1404
FLOW COOLING FLUID THROUGH INTERIOR OF LOWER PUNCH TO EFFECT COOLING
S1405
TAKE OUT SiC IMPREGNATED WITH METAL
S1406
IMPREGNATING STEP
COOLING STEP

FIG. 39



1060
1076
1078
1068
1074a
1074
1078
14
1062
1070
1066
1074b
1020
1080
1064
1072

FIG. 40


INTRODUCE SiC AND METAL INGOTS IN THIS ORDER INTO REFRACTORY VESSEL
S1501
MAKE INTERIOR OF REFRACTORY VESSEL BE IN NEGATIVE PRESSURE STATE
S1502
HEAT AND MELT METAL IN REFRACTORY VESSEL
S1503
PRESSURIZE INTERIOR OF REFRACTORY VESSEL WITH UPPER PUNCH (IMPREGNATION TREATMENT)
S1504
FLOW COOLING FLUID THROUGH INTERIOR OF LOWER PUNCH TO EFFECT COOLING
S1505
TAKE OUT SiC IMPREGNATED WITH METAL
S1506
IMPREGNATING STEP
COOLING STEP